6 Mile/Canyon Creek Landscape Analysis

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Prepared by

Team Leader	**William Shuster**
Recreation/ History	**Dan Lentz**
Minerals	**Carol Huber/Donna Peterson**
Cultural Resources	**Tony Largaespado**
Hydrology/ Limnology	**Bill MacFarlane**
Soils	**Dean Davidson**
Fire	**Mark Black**
Fisheries	**Eric Johansen**
Wildlife	**MaryAnn Benoit**
Vegetation	**Warren Oja**
Ecology	**Elizabeth Bella**

EDITED BY: **WILLIAM SHUSTER**

APPROVED BY: **_/s/ Travis G Moseley** **___4/21/10_________**
Travis Moseley, District Ranger **Date**

TABLE OF CONTENTS

Executive Summary

The 6 Mile and Canyon Creek Landscape Analysis is part of a continuing process to consolidate available information on the watersheds of the forest and assess resource trends within the watersheds over time. The document is intended to be used as a tool to better understand the functioning of resources within the watershed, the changes that have occurred, and the range of management possibilities for the future.

The Landscape Analysis has four chapters. Chapter 1 explains the process used for developing the analysis. It also provides an overview of the resources and history of the 6 Mile and Canyon Creek Watershed.

Chapter 2 evaluates historic/social, physical, and biologic resources within the 6 Mile and Canyon Creek Watershed in greater detail. This chapter examines both “reference” and “current” resource conditions within the watershed. “Reference” conditions consider both the period before 1895 (when gold miners first entered and began to settle in the area), and to the present.

The Chapter 2 resource evaluations provide a compendium of information and data on the 6 Mile and Canyon Creek Watershed gathered from a wide variety of sources. Information sources are referenced at the end of each resource section. Where possible, we have evaluated the quality of the data, and attempted to interpret trends for resource change within the watersheds.

Chapter 3 identifies key issues and questions developed over the course of the analysis. Chapter 3 also highlights resource information gaps identified during the analysis, and possible techniques to obtain missing information.

Chapter 4 presents and discusses a number of recommendations for the various resources and can be used as a tickler possible projects in outyear planning. This document is not a decision making document and each suggested project requires NEPA.

The 6 Mile and Canyon Creek Landscape Analysis compiles, synthesizes, and interprets a large volume of information gathered from numerous sources. Additional information, data and concepts have undoubtedly been overlooked and could likely add to and enrich the content of this document. In this context, we hope to maintain the landscape analysis as a “living” document, so that additional relevant information may be incorporated into the document..

CHAPTER 1- INTRODUCTION AND CHARACTERIZATION

1. Overview of Landscape Analysis

Landscape analysis is used to characterize the human, aquatic, riparian, and terrestrial features; and conditions, processes, and interactions within a watershed. It provides a systematic way to understand and organize ecosystem information. In so doing, landscape analysis enhances our ability to estimate direct, indirect, and cumulative effects of our past management activities and guide the general type, location, and sequence of appropriate future management activities within a watershed.

Landscape analysis is essentially ***ecosystem analysis at the watershed scale.*** It provides a watershed context for fish and wildlife protection, restoration, mitigation, and enhancement efforts. Understandings gained through watershed analysis are critical to sustaining the health and productivity of natural resources. Healthy ecological functions are essential to maintain and create current and future social and economic opportunities.

Federal agencies conduct landscape analyses to shift their focus from species and sites to ecosystems. Working at this scale, we can better understand the overall consequences of potential management actions. Use of the watershed scale allows for selection of a well-defined land area with a set of unique features. Watershed boundaries define a system of recurring physical processes, and a collection of dependent plants and animals. Aquatic resources are particularly well suited to evaluation at the watershed scale.

Landscape analysis is not a decision making process. Rather it is a stage setting process. The results of watershed analysis establish the context for subsequent decision-making processes, including planning, project development, and regulatory compliance.

The results of watershed analysis can be used to:

- Assist in developing ecologically sustainable programs to provide for water, fish and wildlife habitat, recreation, and other commodities.

- Establish a consistent, watershed-wide context for project level National Environmental Policy Act (NEPA) analyses.

- Establish a watershed context for evaluating management activity and project consistency given existing plan objectives.

2. Process and Document Organization

The document is organized around the three primary steps in the process: core topic analysis, answers to key question, and recommendations.
Chapter 2 presents the analysis of core topic areas, as identified in Ecosystem Analysis at the Watershed Scale: Federal Guide for Watershed Analysis (USDA, USDI 1995). The core topic questions focus the basic analysis on ecological conditions, processes, and interactions at work in the watershed. Current and reference conditions and future trends are examined for each core topic area. The core topics address the major ecological elements that are common to watersheds. This is the basic analysis addressed in all watershed analysis documents. The level of detail for each core topic is based on watershed specific issues.

Chapter 3 identifies key questions and issues for a spectrum of resources and activities within the Six Mile/Canyon Creek Watersheds. This chapter identifies information we are lacking in order to make good resource decisions, and where possible, ways of obtaining that information. The chapter includes some recommendations for management within the watershed.

Chapter 4 presents a variety of mitigation and enhancement measures that have arisen and been discussed over the course of developing this watershed analysis. The measures are presented mostly as initial ideas and opportunities. All of the listed measures would require further evaluation and design in order to be considered for implementation.

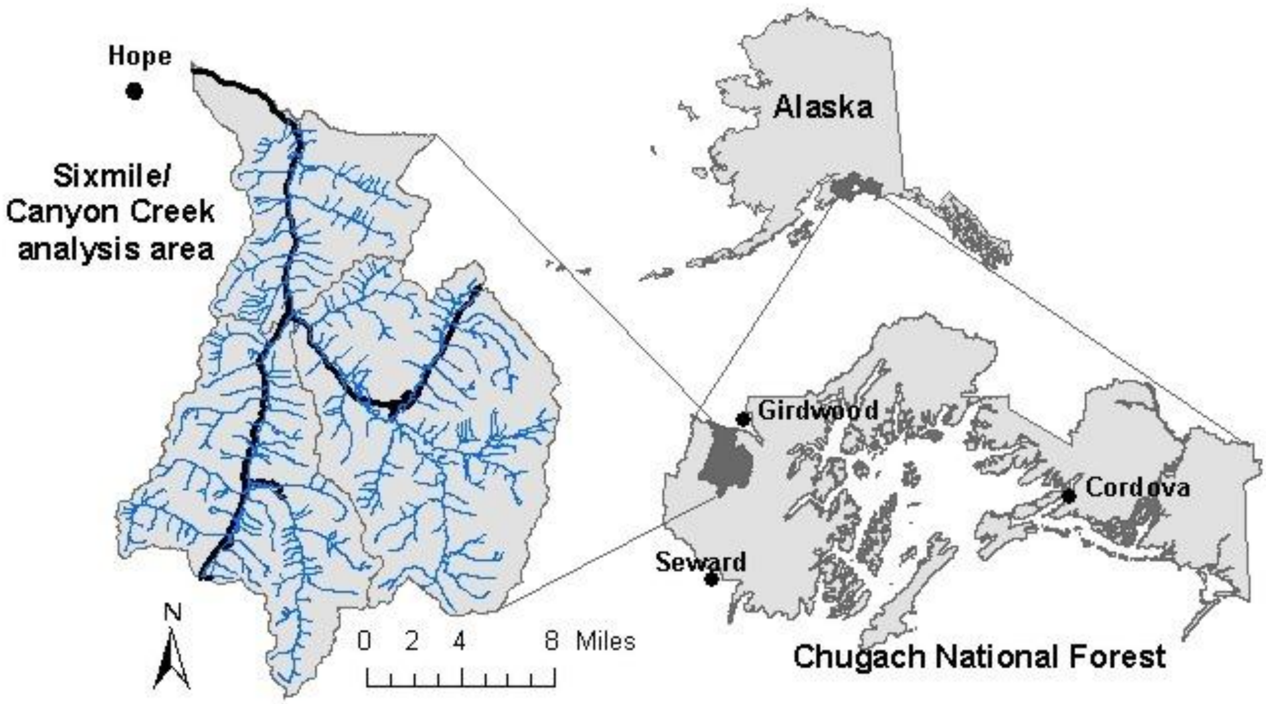
3. Characterization of the 6 Mile/Canyon Creeks Watershed

A. Geographical Setting

The Sixmile/Canyon Creek Landscape Analysis area lies in the northern portion of Alaska's Kenai Peninsula, in the Kenai Mountain Range about 30 miles southeast of Anchorage (**figure 1.III.A-1**). The analysis area is bounded by Turnagain Arm and the Chugach Mountains to the north, the Kenai Mountains to the east and south, and the Resurrection Creek watershed to the west. The analysis area lies within the Seward and

Glacier Ranger Districts of the Chugach National Forest and includes the town of Sunrise, Alaska at the mouth of Sixmile Creek. The analysis area includes Sixmile Creek and its two main tributaries, Canyon Creek and East Fork Sixmile Creek. The Seward Highway follows East Fork Sixmile Creek and Canyon Creek, and the Hope Highway follows lower Sixmile Creek, making a majority of this area easily accessible to the public and popular for many forms of recreation. This area was also a lucrative mining district, containing both placer and lode deposits of gold.

Figure 1.III.A-1: Location of the Sixmile/Canyon Creek analysis area.



6 Mile and Canyon Creek Watershed's Physical Character

B. Sixmile/Canyon Creek Watershed Morphometry

The Sixmile/Canyon Creek analysis area covers approximately 176,019 acres (275 square miles) of mountainous terrain and deep valleys (**figure 1.III.B-1**). The analysis area consists of a total of 30 6th-level subwatersheds draining into Sixmile Creek and its two main tributaries, Canyon Creek and East Fork Sixmile Creek (**figure 1.III.B-2, table 1.III.B-1**).

The Sixmile, East Fork Sixmile, and Canyon Creek valleys are glacially carved U-shaped valleys with steep valley sides leading abruptly to high peaks between 3000 and 5500 feet high. Many short tributaries drain the steep, mountainous, glacially sculpted landscapes. Much of Canyon Creek lies within a deep gorge incised into the glacial valley floor, and both Sixmile Creek and East Fork Sixmile Creek flow through wide valleys containing short, constricted gorges. Small remnant glaciers and permanent snowfields remain throughout the higher elevations of the watershed, covering approximately 6770 acres (10.6 square miles), or 3.9% of the analysis area.

The Sixmile/Canyon Creek watershed flows toward the north, and the aspects of the main channels and tributaries are predominantly north, east, and west. The watershed exhibits a dendritic drainage pattern. Lakes cover a total of 528 acres (0.3%) of the analysis area. Summit Lake, covering 243 acres, and Lower Summit Lake, covering 50 acres, are situated at about 1300 feet in elevation near the headwaters of Canyon Creek. Bench Lake, covering 94 acres, lies at about 1500 feet in elevation near the summit of Johnson Pass. Each of these natural lakes was created by the damming effect of alluvial fans. Many small glacially formed lakes are scattered throughout the analysis area, generally formed within cirque basins or by terminal moraine deposits.

Figure 1.III.B-1: Sixmile Creek watershed, looking south up Sixmile Creek and Canyon Creek from Turnagain Arm.

Figure 1.III.B-2: Sixmile/Canyon Creek analysis area watersheds and subwatersheds. Stream and watershed data from USDA Forest Service. Stream data updated 1998, watershed data updated 1997.

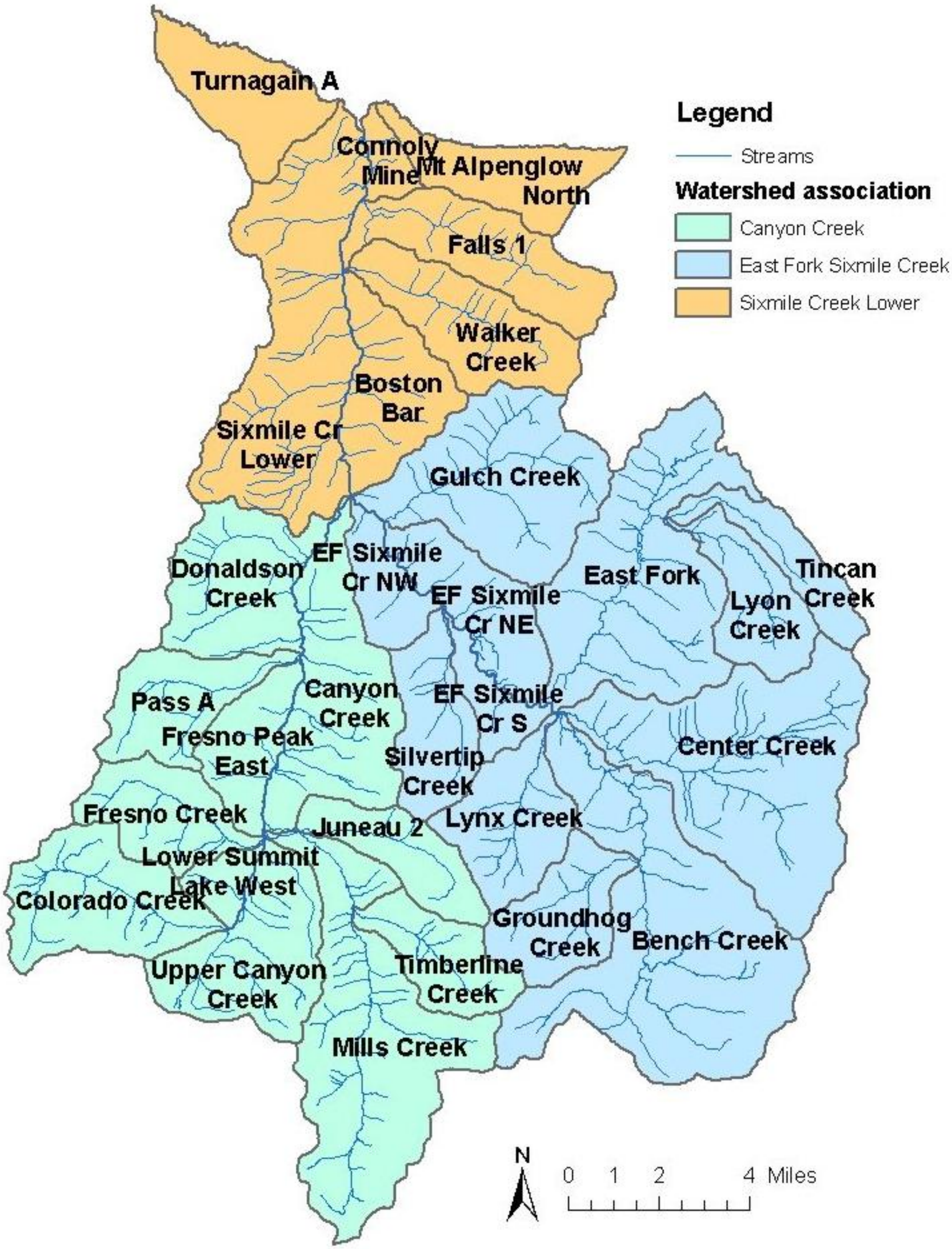


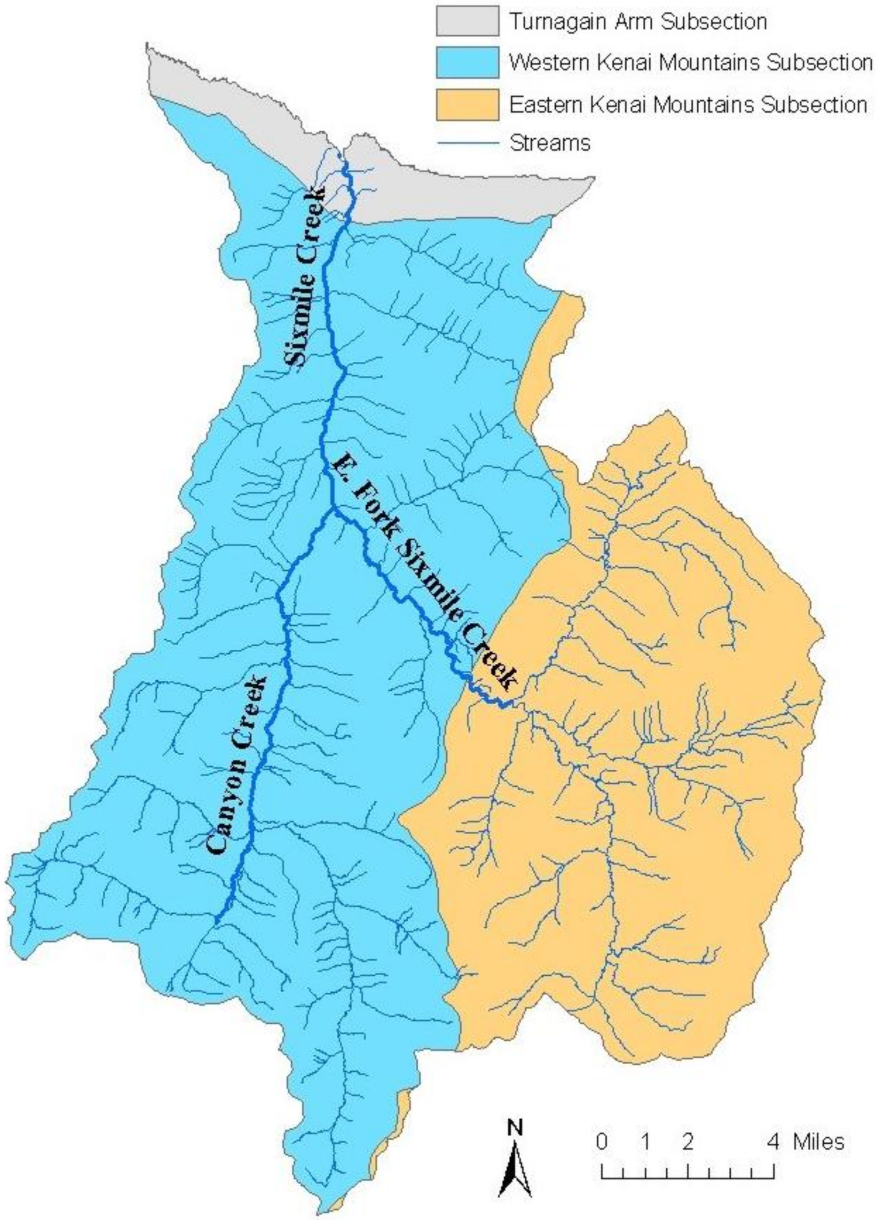
Table 1.III.B-1: Characteristics of watersheds and subwatersheds in the Sixmile/Canyon Creek analysis area.

	Subwatershed	Drainage Area		Approx Max elevation (ft)	Approx Min elevation (ft)
		mi^2	acres		
Sixmile Creek Lower Watershed: 60.1 mi^2 (38,471 acres)					
	Turnagain A	7.00	4,481	4600	0
	Sixmile Creek Lower	20.37	13,038	4600	0
	Connoly Mine	1.61	1,028	2550	0
	Mt Alpenglow North	6.18	3,956	4800	0
	Falls 1	8.77	5,613	4800	60
	Walker Creek	8.67	5,550	4500	150
	Boston Bar	7.51	4,804	4500	150
Canyon Creek Watershed: 90.9 mi^2 (58,182 acres)					
	Donaldson Creek	9.26	5,928	5079	400
	Canyon Creek	12.07	7,725	5000	400
	Pass A	6.44	4,122	4762	730
	Fresno Peak East	4.76	3,045	4000	730
	Fresno Creek	6.20	3,971	4687	1160
	Colorado Creek	9.87	6,317	4982	1300
	Lower Summit Lake West	1.80	1,152	4100	1160
	Upper Canyon Creek	9.87	6,318	5000	1160
	Juneau 2	5.22	3,343	5000	1400
	Mills Creek	20.04	12,823	5200	1150
	Timberline Creek	5.37	3,438	4800	1400
East Fork Sixmile Creek Watershed: 124.0 mi^2 (79,366 acres)					
	Gulch Creek	14.45	9,250	4900	400
	E Fork Sixmile Creek NW	3.53	2,260	4000	400
	E Fork Sixmile Creek NE	6.67	4,270	4900	440
	Silvertip Creek	6.14	3,928	5000	530
	East Fork Sixmile Creek S	2.57	1,642	3800	530
	East Fork	19.20	12,291	4900	640
	Tincan Creek	4.28	2,737	4600	950
	Lyon Creek	5.81	3,720	4700	950
	Center Creek	21.93	14,032	5575	650
	Bench Creek	25.69	16,444	5575	650
	Lynx Creek	7.33	4,690	4600	650

	Groundhog Creek	6.41	4,101	4800	900
TOTAL		**275.0**	**176,019**		

As classified by ecological subsection, a total of 104,490 acres (59.4%) of the analysis area lie within the Western Kenai Mountain Subsection of the Kenai Mountain Section (Davidson, 1997; USDA Forest Service, 1997) (**figure 1.III.B-3**). This subsection is characterized by rounded mountains shaped by frost in a relatively cold and dry climate, and large valleys created by glaciers originating in the Eastern Kenai Mountains Subsection. A total of 63,888 acres (36.3%) of the analysis area lie within the Eastern Kenai Mountain Subsection of the Kenai Mountain Section. This subsection is characterized by relatively jagged mountains, many containing alpine glaciers, and glacial alpine valleys containing substantial glacial till and outwash deposits. A total of 7641 acres (4.3%) of the analysis area lie within the Turnagain Arm Subsection of the Kenai Mountains Section. This subsection is adjacent to Turnagain Arm and includes broad glacial outwash plains and wetlands, and steep, rocky, glaciated sideslopes.

Figure 1.III.B-3: Ecological subsections of the Sixmile Creek watershed. Data from USDA Forest Service, updated 1997. Subsections were based on general biotic and environmental factors and were delineated with a minimum cell size of five acres.



Elevations in the analysis area range from sea level at the mouth of Sixmile Creek to 5575 feet at Bench Peak in the southeast portion of the watershed. Of the 176,019 acres in the analysis area, only 12.2% of the area is less than 1000 feet in elevation, and the majority of the area lies between 1000 and 4000 feet in elevation **(figure 1.III.B-4)**. Hillslope gradients within the analysis area range from 0% to greater than 100%. Only 20.7% of the watershed area consists of slopes less than 20%, and the majority of the watershed consists of slopes between 20% and 80% (**figure 1.III.B-5**).

Figure 1.III.B-4: Distribution of watershed area by elevation. Data from USDA Forest Service.

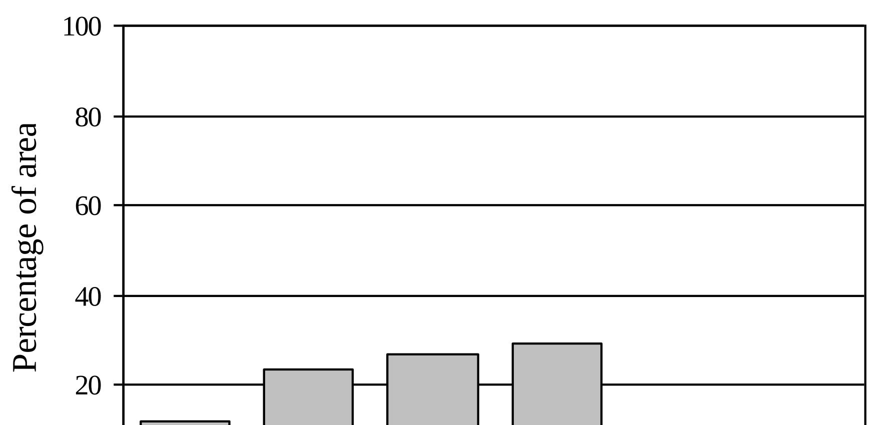
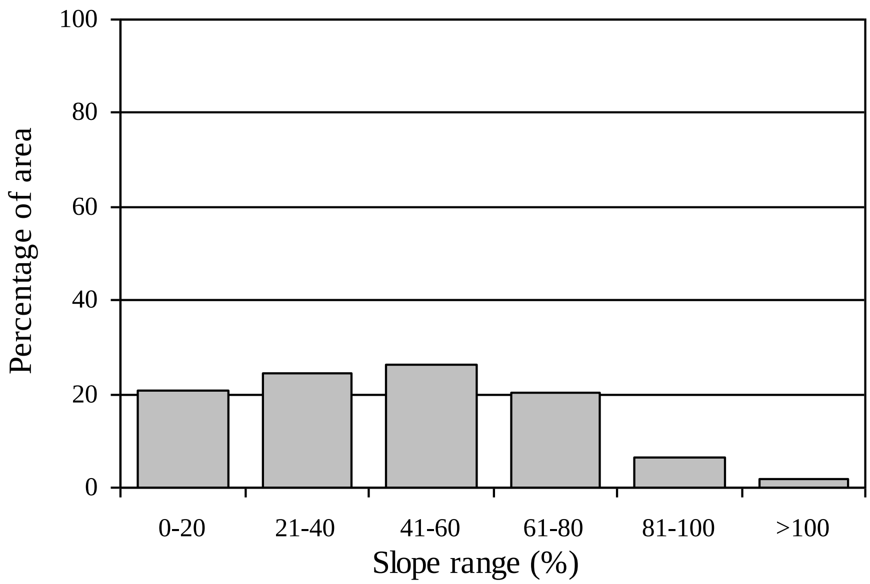
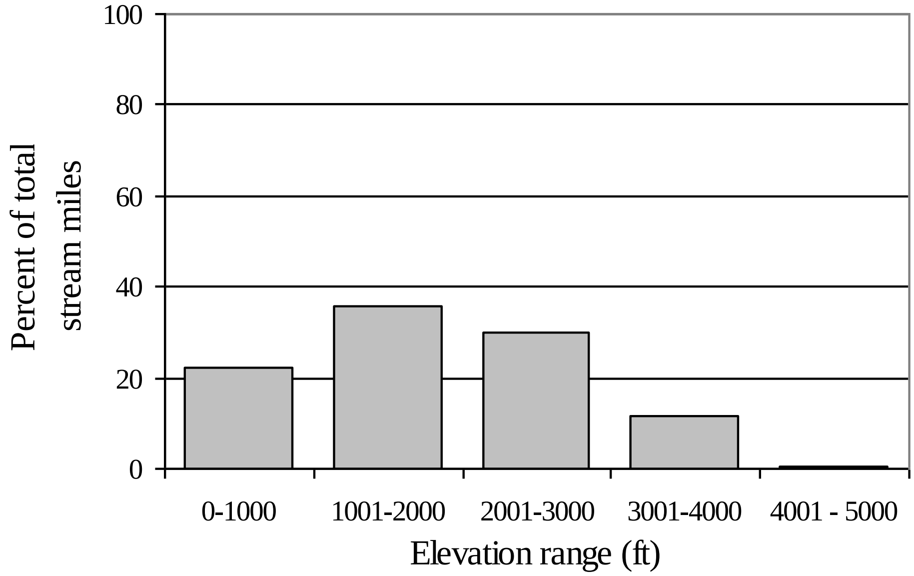


Figure 1.III.B-5: Distribution of watershed area by slope. Data from USDA Forest Service.



A total of 422 miles of stream lie within the Sixmile/Canyon Creek analysis area, delineated using 1:63,360 USGS orthophoto quads magnified to a scale of 1:31,380 (USDA Forest Service, 1998). This represents a drainage density of approximately 1.5 stream miles per square mile of area. The largest streams in the analysis area are Sixmile Creek and its two tributaries, Canyon Creek and East Fork Sixmile Creek. Only 22% of the streams in the analysis area are at elevations less than 1000 feet, and the majority of streams are between 1000 and 3000 feet in elevation (**figure 1.III.B-6**).

Figure 1.III.B-6: Distribution of stream miles by elevation. Data from USDA Forest Service.



Streams in the Chugach National Forest were classified using a system developed by the Tongass National Forest (USDA Forest Service, 1992), and classifications were based on aerial photography and field verification (**figure 1.III.B-7**, **table 1.III.B-2**). The majority of the channels in the Sixmile/Canyon Creek analysis area (68%) are in the High Gradient Contained process group (HC). These headwater mountain slope channels generally have gradients greater than 6% and act as primary sediment source zones with high stream energy that enables them to transport large sediment loads during high flows.   Many of the larger tributaries to Canyon Creek, East Fork Sixmile Creek, and Sixmile Creek are predominantly Deeply Incised Upper Valley channels (HC3). The lower reaches of many of these tributary channels are classified as Shallowly to Moderately Incised Footslope channels (HC2). The uppermost tributaries throughout the watershed are classified as Shallowly Incised Very High Gradient channels (HC5) and Deeply Incised Mountain slope channels (HC6). 9.2% of the channels in the Sixmile Creek watershed are in the Flood Plain process group (FP). These channels generally have gradients less than 2% and occupy the lowlands of larger valleys, allowing for alluvial deposition in the floodplains during high flows. 8.2% of the channels are in the Moderate Gradient Mixed Control process group (MM). These channels generally have gradients ranging from 2% to 6%, and sediment deposition and floodplains are limited.

Figure 1.III.B-7: Stream classification in the Sixmile/Canyon Creek analysis area. Data from USDA Forest Service, updated 1998. Streams were delineated from 1:31,680 USGS orthophoto quadrangles, and channel types were assigned based on aerial photography and field verification, using the Tongass National Forest classification system (USDA Forest Service, Alaska Region, 1992). See Table 1.III.B-2 for tabulation of stream miles.

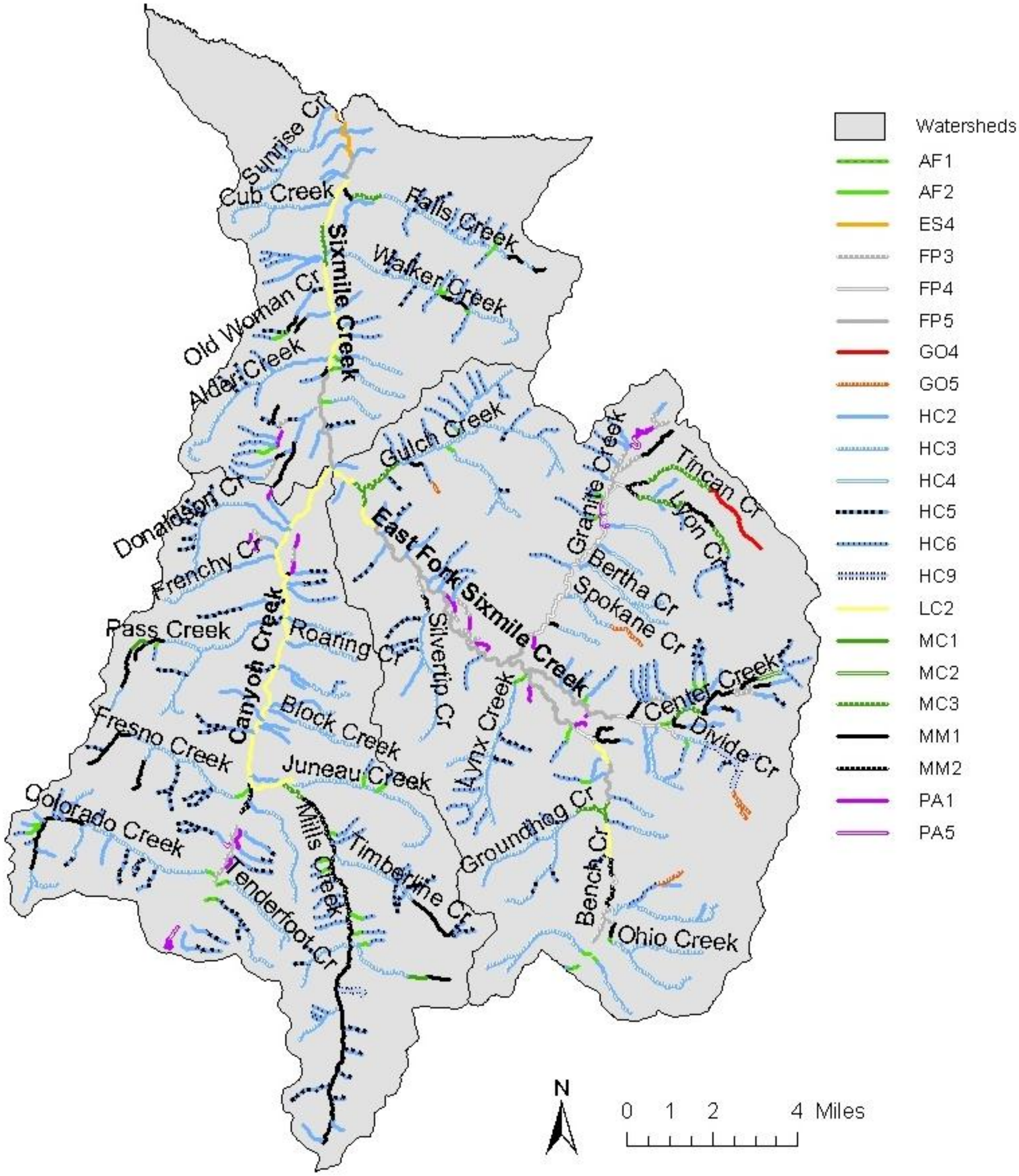


Table 1.III.B-2: Channel types within the Sixmile/Canyon Creek analysis area. Classification system from USDA Forest Service, Alaska Region (1992). Data from USDA Forest Service, updated 1998.

Code	Channel type description	Stream miles	% of total
AF1	Moderate Gradient Alluvial Fan Channel	2.17	0.51
AF2	High Gradient Alluvial Cone Channel	9.29	2.20
ES4	Large Estuarine Channel	1.03	0.24
FP3	Narrow Low Gradient Flood Plain Channel	12.10	2.87
FP4	Low Gradient Flood Plain Channel	9.09	2.16
FP5	Wide Low Gradient Flood Plain Channel	17.53	4.16
GO4	Moderate Width Glacial Channel	2.05	0.49
GO5	Cirque Channel	3.24	0.77
HC2	Shallowly to Moderately Incised Footslope Channel	63.69	15.10
HC3	Deeply Incised Upper Valley Channel	111.64	26.47
HC4	Deeply Incised Muskeg Channel	2.09	0.50
HC5	Shallowly Incised Very High Gradient Channel	45.26	10.73
HC6	Deeply Incised Mountainslope Channel	62.42	14.80
HC9	High Gradient Incised Glacial Torrent Channel	2.94	0.70
LC2	Moderate Gradient Contained Narrow Valley Channel	17.41	4.13
MC1	Narrow Shallow Contained Channel	0.97	0.23
MC2	Moderate Width and Incision, Contained Channel	0.57	0.13
MC3	Deeply Incised Contained Channel	10.40	2.47
MM1	Narrow Mixed Control Channel	27.56	6.54
MM2	Moderate Width Mixed Control Channel	6.90	1.64
PA1	Narrow Placid Flow Channel	6.51	1.54
PA5	Beaver Dam/Pond Channel	2.07	0.49
L	Lakes	4.77	1.13

TOTAL	**421.7**	**100**

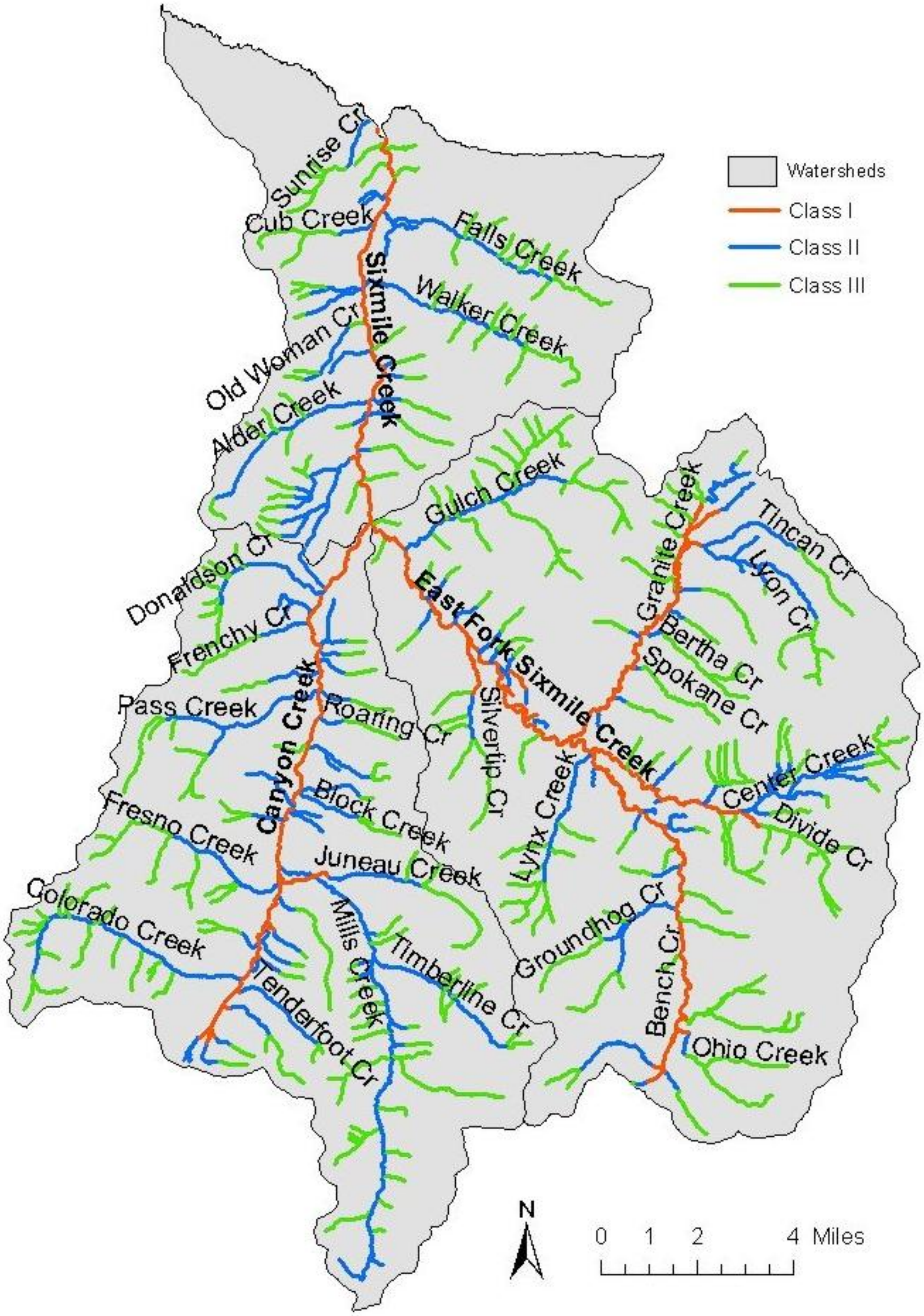
B. Fisheries

Streams in the analysis area were also classified by their fish habitat stream class values (**figure 1.III.B-8, table 1.III.B-3**), using the classification system developed by the Tongass National Forest (USDA Forest Service, Alaska Region, 1992). Streams were classified based on aerial photography and field verification. The majority of the streams in the Sixmile/Canyon Creek analysis area (52.5 %) are Class III streams, or high gradient headwater streams that do not support fish habitat. The lower portions of the smaller tributary streams, as well as the larger tributaries of Canyon Creek, East Fork Sixmile Creek, and Sixmile Creek are generally Class II streams, or steep streams that contain resident fish populations. Only the largest streams in the analysis area are Class I streams, or those that have anadromous stream habitat. The only Class I streams in the Sixmile/Canyon Creek analysis area are Sixmile Creek, Canyon Creek, East Fork Sixmile Creek, Granite Creek, Center Creek, and Bench Creek.

Table 1.III.B-3: Fish habitat stream classification (USDA Forest Service, AK Region, 1992) in the Sixmile/Canyon Creek analysis area. Data from USDA Forest Service, updated 1998.

Class	Description	Miles of stream	Percent of total
Class I	Streams with anadromous or adfluvial lake and stream habitat	62.8	14.9
Class II	Streams with resident fish populations. Generally steep (6-15% gradient), can include streams from 0-5% gradient without anadromous fish	137.4	32.6
Class III	Streams with no fish populations that have potential water quality influence on downstream aquatic habitats	221.5	52.5

Figure 1.III.B-8: Fish habitat stream classification in the Sixmile/Canyon Creek analysis area. Data from USDA Forest Service, updated 1998. Streams delineated from 1:31,680 USGS orthophoto quadrangles, and channel types assigned based on aerial photography and field verification using the Tongass National Forest classification system (USDA Forest Service, Alaska Region, 1992). See Table 1.III.B-3 for channel type descriptions.


Watersheds
Class I
Class II
Class III
Sunrise Cr
Cub Creek
Falls Creek
Sixmile Creek
Walker Creek
Old Woman Cr
Alder Creek
Gulch Creek
Granite Creek
Tincan Cr
Lyon Cr
Donaldson Cr
East Fork Sixmile Creek
Bertha Cr
Frenchy Cr
Spokane Cr
Silvertip Cr
Pass Creek
Canyon Creek
Roaring Cr
Lynx Creek
Center Creek
Block Creek
Divide Cr
Fresno Creek
Juneau Creek
Colorado Creek
Mills Creek
Groundhog Cr
Timberline Cr
Tenderfoot Cr
Bench Cr
Ohio Creek
N
0 1 2 4 Miles

C. Regional Geology

The assessment area lies within the Upper Cretaceous Valdez Group metamorphic sequence of rocks (Tysdal and Case, 1979). This group crops out in the western and northern portions of the Chugach National Forest as an arcuate-shaped band of rocks consisting primarily of a slightly metamorphosed, steeply dipping, marine clastic (flysch[1]) sequence. These rocks formed from sediments deposited by turbidity currents in a marine environment. Later they were swept into a subduction trench and metamorphosed. These rocks are speculated to have accreted to the southern Alaska mainland during late Cretaceous and early Tertiary time (Hoekzema, 1986). The thickness of the Valdez Group is unknown, but is believed to be at least several miles thick.

Winkler and others (1984) reported that the deformation and metamorphism of the Valdez Group occurred between 65 and 50 million years ago. The metamorphic grade of Valdez Group rocks ranges from prehnite-pumpellyite to amphibolite facies, with rocks of the lower greenschist facies being widespread and particularly well displayed in pelitic or volcanic sequences.

Two prominent sets of faults occur in Valdez Group rock. Regionally, the most apparent occur as relatively widely spaced (several miles) north-northeast striking steeply west-dipping, longitudal faults. These faults are diagonal-slip faults. The other prominent set of faults is the smaller, closely spaced (hundreds of feet) parallel faults (shear zones) that are recognized throughout the area. Locally, older faults occur as relatively close-spaced (50 to 500 feet) west- to northwest-striking, steeply dipping transverse faults.

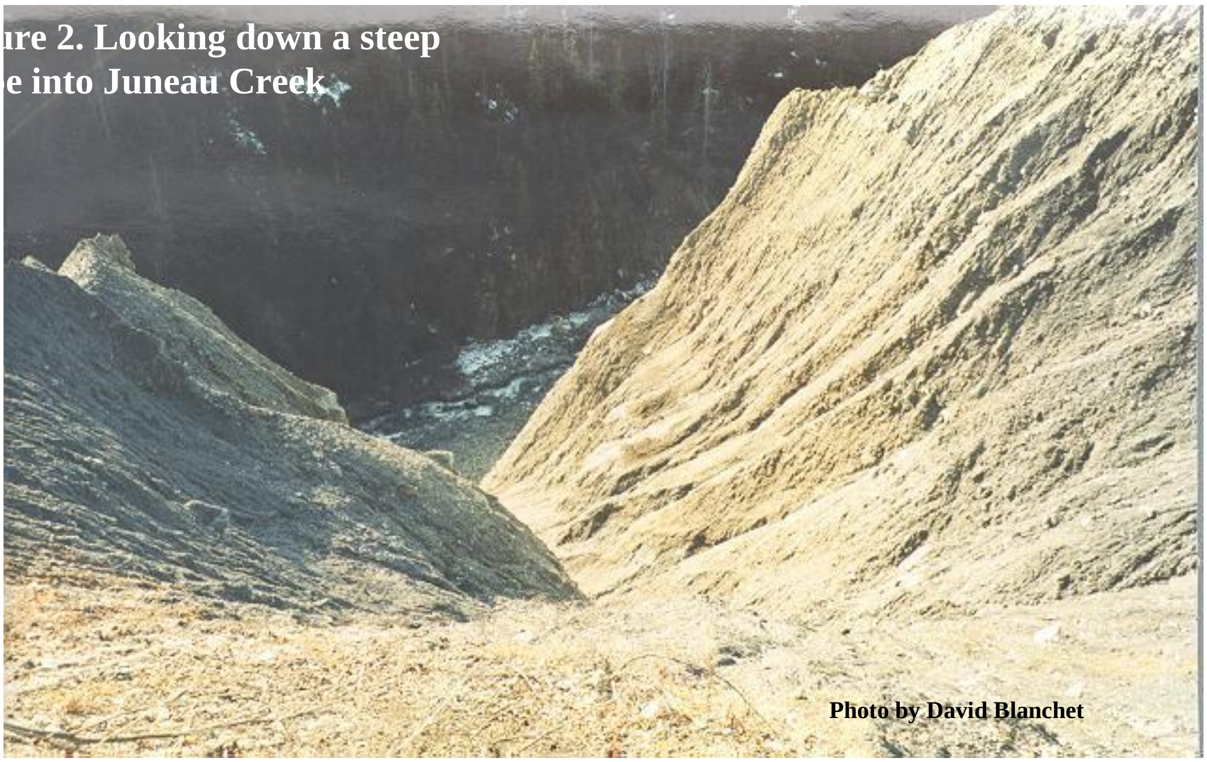
D. Local Geology

Bedrock in the assessment area is Upper Cretaceous Valdez Group metasedimentary rock (Kv) (Attachment 1); it is composed of rhythmically interbedded slate and greywacke. Slate is particularly abundant in a belt several miles wide that trends roughly northeast through Gilpatrick Mountain toward Bird Point (Tysdal and Case, 1979). In the southwestern portion of the assessment area a felsic dike known as the Gilpatrick Dike intrudes the Valdez group. It is exposed intermittently and is as much as 15 feet wide in places. The Gilpatrick Dike trends generally northeasterly and is roughly parallel to Canyon Creek. The dike is associated with a number of lode gold prospects and occurrences in the area. The Mascot dike outcrops at the S-263 site, shown on Attachment

[1] A collection of marine sediments shed by a rising mountain chain as it is uplifted and eroded. The sediments are mainly silt and sand.

1 west of the Gilpatrick Dike and in the southwest portion of the assessment area. Geology, lode prospects and one lode mine are shown on Attachment 1.

A large, active area of mass wasting exists along the Juneau Creek, on the north side of Juneau Creek just upstream of its confluence with Mills Creek (Figure 2). Seasonal high water flows erode the toe of the steep, unstable slope. Spring freeze-thaw cycles and soil saturation from snowmelt in the upper layers of the slope cause mudflows into Juneau Creek. These naturally occurring mudflows greatly increase the turbidity of Mills Creek and Canyon Creek downstream at times. The erosion in this area is affecting an old mining access road that just this year (2002) has been closed to vehicle traffic.



ure 2. Looking down a steep
e into Juneau Creek

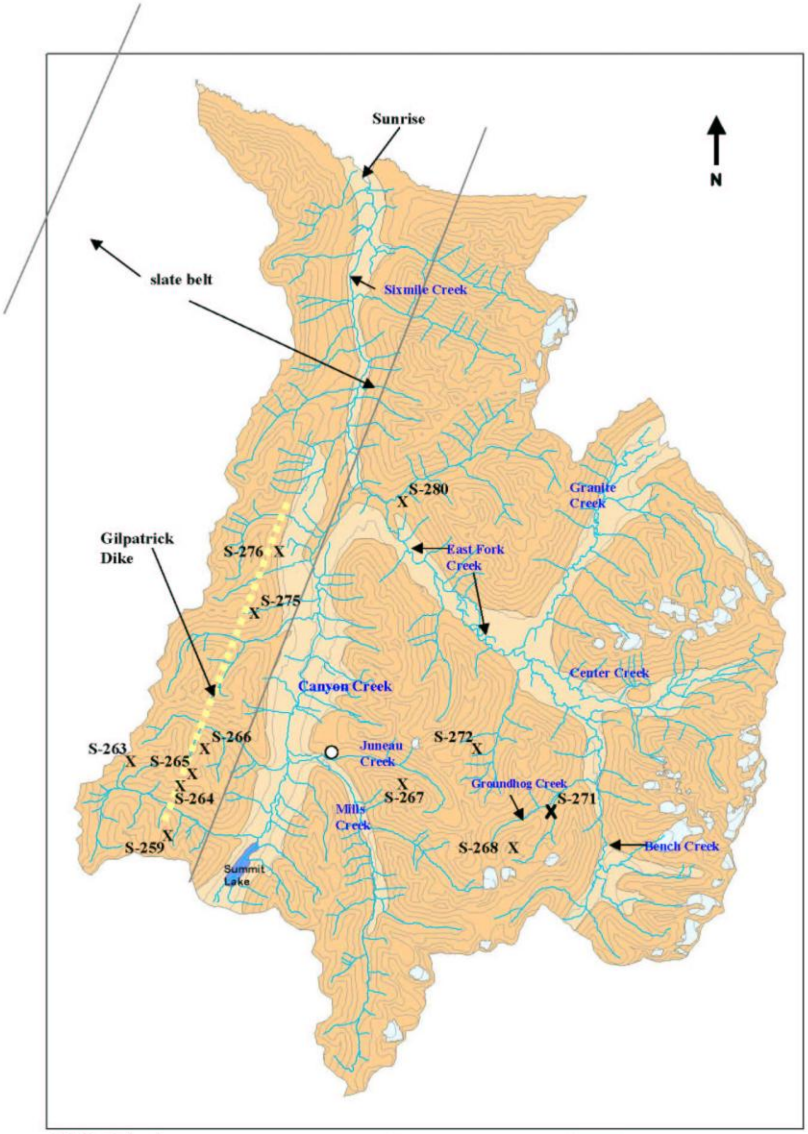
Unconsolidated Quaternary-age surficial deposits (Attachment 1) consist predominantly of alluvium deposited by nonglacial streams and outwash deposited by glacial melt water (Nelson and others, 1985). They consist of sand and gravel; terminal, lateral, and ground moraines composed of unsorted deposits of boulders, cobbles, gravel and sand left by the retreat of alpine, valley and regional glaciers; and talus and landslide deposits consisting of coarse angular rock debris derived from adjacent bedrock. Alluvial deposits occur primarily along Canyon, East Fork, Granite, Center, Bench, Sixmile, and Mills Creeks.

These alluvial deposits are potential sources of sand and gravel, and in some places, placer gold. Major placer gold producing streams are shown on Attachment 2.

The Valdez Group is known to host small high-grade lode gold deposits, and streams draining the unit commonly contain auriferous[2] gravels. Copper nuggets occur at Lynx Creek; this is the only known copper occurrence within the Valdez Group. Mineral materials consisting of rock and gravel are common and have been extracted along the road corridor in numerous locations. Gravel has been used for road and other general construction purposes. Slate rock has been used as decorative building stone and for walkways. No leasable minerals such as oil and gas are known to exist. Then Valdez Group is not known to host these types of deposits. Deposits that occur in the assessment area are discussed in detail in the sections below.

[2] gold-bearing

Attachment 1. Geology, Lode Gold Mines and Prospects of the Sixmile/Canyon Creek Landscape Assessment Area



S-259 – Colorado
S-263 – Mascot; Iron Mask
S-264 – Independence
S-265 – Fresno 1 & 2; June Mine
S-266 – Shell Mine
S-267 – Teresa 1-6
S-268 – Seward Gold; Telluride
S-271 – Brewster
S-272 – Ready Bullion
S-275 – Gilpatrick (different than Gilpatrick Mine)
S-276 - Hillside
S-280 – Julia; Silvia
(From Jansons and others, 1984)

O Juneau Creek landslide
X Prospect
X Mine

Kv – sedimentary rocks, undivided

Qs – Unconsolidated surficial deposits

E. Cultural and Mining History

Figure 3. This photo is Wible on Canyon Creek, 1904. Photo shows high gravels on the right. The trestlework formerly carried a flume.

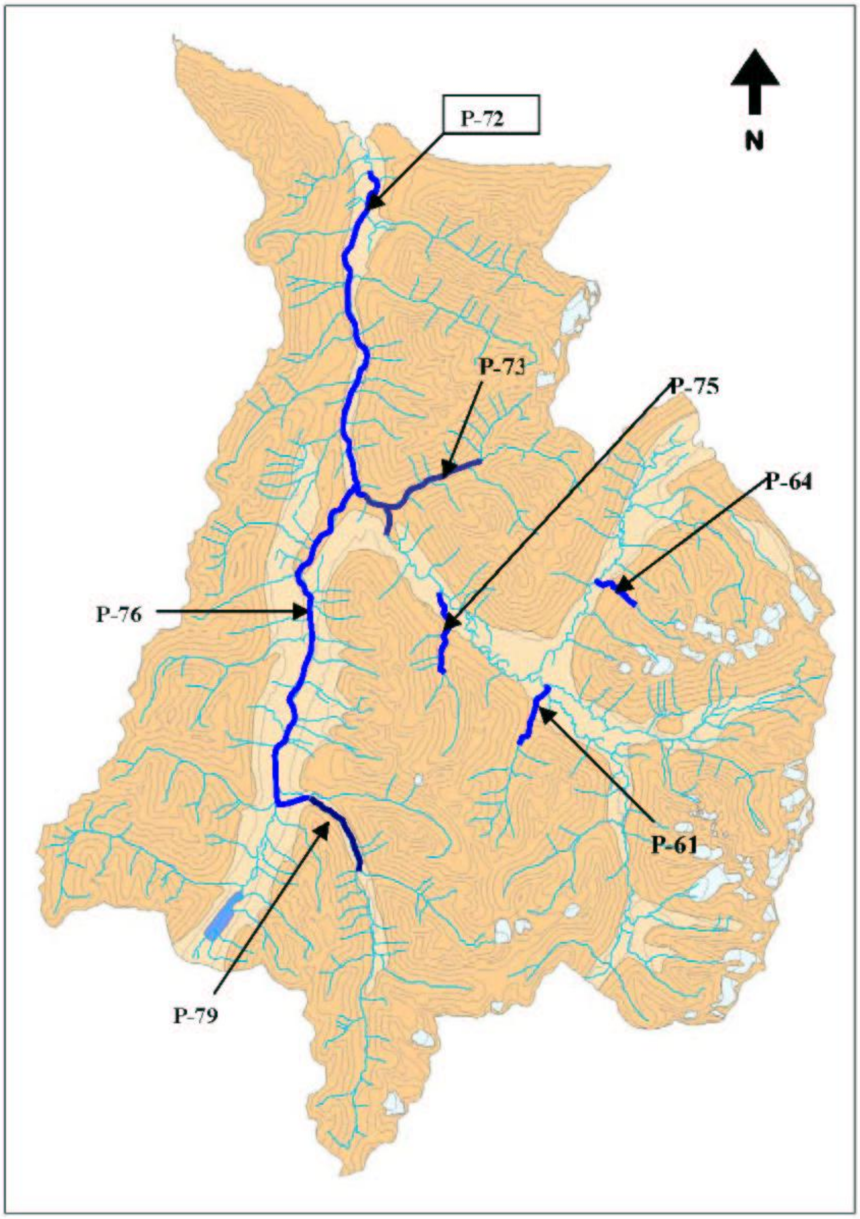
The first attempt to develop the mineral resources of Alaska was made in 1848 by Peter Doroshin, a Russian mining engineer, who was sent from St. Petersburg by the Russian-American Company to examine Baranof Island and the Cook Inlet Region. After the original placer discovery in 1848, Doroshin did further exploration along the Kenai River in 1850 and 1851, but was not successful in locating economic deposits of gold.

Figure 4. East Fork Sixmile Creek in 1904. Wing dam on right. Moffit, 1906

In about 1888, placer gold was discovered in the Turnagain Arm field by a man named King who reportedly found gold near Hope. Gold was subsequently discovered on Palmer Creek in 1894. These discoveries led to prospecting on neighboring streams and in 1895, claims were staked on Mills Creek. Mr. Mills at the same time staked ground at the forks of Sixmile Creek. Another notable discovery in 1895 was made on Lynx Creek. About this time an assemblage of miners formed the Sunrise mining district and elected a local recorder. A few years later this recording precinct was united with the older Turnagain Arm district and the books of the recorder were removed to Seward, where they currently reside. Discoveries in1896 on both Mills and Canyon Creeks brought a rush of prospectors to the area, and on Canyon Creek alone, 327 men were engaged in mining that year. The first rush of prospectors into the area was said to be several thousand, some state as high as 3,000. A second rush into the Turnagain Arm field took place in 1898. This was partly an overflow from the Yukon stampede and was not entirely due to successes on Resurrection and Sixmile Creeks. Most of the first men who entered the field were experienced miners. On the other hand, most of the latecomers were inexperienced in any kind of mining. According to Moffit, 1906, “It is doubtful if there is any other part of Alaska where time and money have been wasted in a more enthusiastically ignorant manner or concerning which stockholders in mining companies have been more utterly misled than some places on the Kenai Peninsula. The field did not justify the presence of any such number as came and disappointment was the only result possible for most of them.”

Following the gold “rush” around the turn of the century and the initial surge of gold production, mining activity and production decreased quickly. This was due to the fact that the deposits which could be easily worked profitably by hand methods were exhausted and also due to the small size of higher grade deposits which were usually confined to the channels of the present day stream courses. Substantial amount of lower grade stream placer and low-grade glacial deposits remained but these required the development of hydraulic mining systems and considerable capital investment. By 1908 there were approximately 50 men working on 10 claims in the area. In 1931 only 20 men worked mines in the Moose Pass and Hope Mining Districts. The town of Sunrise had dwindled to a population of 2 people by 1930.

Attachment 2 - Major placer deposits in the Sixmile/Canyon Creek Landscape Assessment Area



Lode Gold

A. Geology and Deposit Types

The origin of gold-quartz vein deposits is controversial among geologists working in the assessment area and other greywacke-slate terranes similar to the Valdez Group. Numerous investigators have attempted to relate such deposits to orogenic[3] related magmatic[4] events; others argue that they can be related to metamorphic[5] processes. Gold is hosted in quartz veins related to intrusive felsic[6] bodies (Gilpatrick Dike) and other gold-quartz veins show no such relationship. However, nearly all types of epigenetic[7] gold-quartz vein deposits are restricted to rock with a low to moderate degree of metamorphism (greenschist to amphibolite facies). There are three primary types of lode gold deposits within the assessment area. These are discussed in detail below.

Type 1. Quartz-carbonate veins hosted by fractured felsic dikes occur in the Summit Lake and Hope areas. Sulfide mineral content is low and generally makes up to 3% of the quartz and includes arsenopyrite, pyrite chalcopyrite, galena, sphalerite, and pyrrohite. Arsenopyrite occurs in the dike rock. Gold is primarily associated with galena and sphalerite. Gold grade tends to be low but locally may be high grade. The Gilpatrick Mine (S-253[8]) is the only producer of this deposit type. It is located on the west side of the Seward highway within 2-3 miles south of the assessment area. Prospects of this deposit type include Fresno 1 and 2 (S-265), Mascot and Iron Mask (S-263), Colorado Group (S-259), Independence (S-264), Gilpatrick (S-275), and Shell Mine (S-266); prospects are shown on map in Attachment 1. (The Shell Mine is not actually a mine; it has had no production but has been named “Shell Mine”).

Type 2. Quartz-carbonate veins spatially associated with but not in contact with felsic dikes occur within the Summit Lake and Hope areas. Sulfide content ranges from 1% to 2% and includes arsenopyrite, galena, sphalerite, pyrite, and chalcopyrite. Gold is primarily associated with galena. Gold grade tends to be high, but the deposit size is small. Production has occurred from the Ronan & James, and Oracle Mines; both are within 2-3 miles south of the assessment area. One such prospect is Hillside Quartz/Frenchy Creek Mine (S-276). (Frenchy Creek Mine is the name but it is not actually a mine; it has had no production.)

[3] mountain-building
[4] pertaining to magma or molten rock
[5] to change, processes such as heat or pressure which alter rock composition and/or structure
[6] light colored intrusive rock consisting mainly of feldspar and quartz
[7] produced on or near the earth’s surface
[8] This id number is from a 1984 BuMines published report, “Mineral Occurrences in the Chugach National Forest, Southcentral Alaska” by Jansons and others.

Type 3. Quartz veins not spatially associated with dikes or stocks and with low sulfide content occur within the assessment area and in the Moose Pass area. The sulfide mineral content is low, usually less than 1% and includes arsenopyrite, galena, chalcopyrite, pyrite and sphalerite. Grade is generally high but deposit size is small. Several properties had production; the largest producer was the Crown Point mine with 3,125 ounces of gold and 634 ounces of silver. One of the producers (Brewster, S-271) is within the assessment area. A prospect within the assessment area of this deposit type is Seward Gold (S-268)

Type 4. Quartz and/or quartz-carbonate veins containing high silver values with little gold occur in the Gulch Creek area. Sulfide minerals locally make up to 25% of the vein and include galena, stibnite, sphalerite, chalcopyrite, arsenopyrite, and pyrrohite. Veins occur in slate and metagraywacke and some are associated with felsic dikes. There are no producing properties of this deposit type. An occurrence of this deposit type is Gulch Creek No. 1 (S-281).

B. Mining and Production History

The first lode claims on the Kenai Peninsula were located during 1896 in Bear Creek, Palmer Creek, Sawmill Creek and Summit Creek. The majority of lode discoveries in the vicinity were made in the early part of the 19th century. Gold production from the lode claims has not been large. The most recent lode gold production in the Chugach National Forest was in the 1930s and 1940s when records show that gold was sold to the U.S. Mint at Seattle. There has been little or no lode gold mining activity since 1956.

There are 11 lode gold prospects[9] known in the literature within the assessment area, but only one past producer (Attachment 1). The Brewster mine (S-271) produced a reported 5 – 10 ounces of gold in 1926. Wimmer (1926) reports, "The deposit offers absolutely no encouragement for further development." The mine is located at an elevation of 1,780 feet near the confluence of Groundhog and Bench Creek. The workings consist of a 65-foot-long adit and improvements include of a small mill. An overgrown trail is visible from the air, along Groundhog Creek for about ½ mile.

There are several lode gold mines[10] near the assessment area. One of these is the Kenai Lu (Kirsten 1 and 2). This mine consists of a 60- to 70-foot-long adit, which produced twenty-five ounces of gold in 1906. Within 5 miles south of the assessment area, there are two lode mines: the Gilpatrick Dike mine and the Heaston-Oracle mine. The Gilpatrick Dike mine has 500 feet of workings with a recorded production of 3,405 ounces of gold

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[9] Sites with workings such as adits and shafts, but with no production are "prospect(s)".
[10] The term "mine" as used here means that there has been production.

and 1,099 ounces of silver. The patented Heaston-Oracle mine has a reported production of 1,274 ounces of gold and 256 ounces of silver.

F. Recreation

Recreationists utilize portions of the analysis area, with some areas being used more than others, and due to steep terrain some areas are utilized solely for scenery viewing. The used areas are in the form of hikers, backpackers, campers, recreational gold panners, bicyclists, horseback riders, hunters, fishermen, highway sightseers, cross-country skiers, recreation cabin users, and snowmachiners. These uses are generally restricted to a very limited area in direct association with the Johnson Pass, Summit Creek, and Gulch Creek Trails, rafting on the Sixmile Creek, the Tenderfoot, Granite Creek and Bertha Creek Campgrounds, as well as the popular Turnagain Pass Winter Sports Area, the Recreational Gold Panning area along the Sixmile Creek, recreation use at Manitoba Cabin, rafting of the Sixmile Creek, and scenic viewing/driving along State Highway 1 and Forest Highway 14. The analysis area also has unknown historic and prehistoric archaeological resources that will need to be protected. The Seward RD is also in the early stages of planning for the reconstruction and construction of the Iditarod National Historic Trail (Iditarod NHT), which will bisect the planning area with potential locations utilizing the Johnson Pass Trail and areas along State Highway 1.

<u>Trails</u>:
A portion of the Johnson Pass Trail is within the analysis area. There are approximately nine miles and one trailhead associated with this trail. A small portion of the Summit Creek Trail is within this analysis area. This consists of the trailhead and approximately ½ mile of the trail.

The Gulch Creek Trail was developed by miners to access claims up Gulch Creek. The trail begins on the north side of Sixmile Creek and climbs along the southwest side of Gulch Creek leading up the valley for approximately one mile. Old mining structures still used by claimants are located about one mile up Gulch Creek on the east side of Gulch Creek. There is a new bridge accessing the trail, which spans the East Fork Sixmile Creek, which was installed in the summer of 2002. A new trailhead is currently being considered for this trail.

The Sixmile Creek access trails have been developed over many years. Some have been brushed out recently to provide access to the creek below several rapids. These are used primarily by rafters (commercial and private) for scouting water levels and for ground support while rafts go through the rapids. Two of the trails are very steep and ropes have been put in by outfitter guide companies to descend into the 3rd canyon.

There are also seven other lesser-identified trails within the planning area. These trails were previously identified and named in a historic document (Summit Lake Recreation Area, date unknown) located on the Seward Ranger District. They are identified as the Summit Lodge Trail, Fresno Mining Trail, Southeast Slope, Whitey's Trail, Pass Creek Wedge, Frenchy Creek Area, and the Clinton Creek Shield. Many of these are believed to be only cross-country type of trails that can be accessed after significant snowfall, but are not physically established trails on-the-ground. It would be interesting to try to re-locate and/or reestablish these trails utilizing the descriptive locations identified in the above referenced document.

Campgrounds and Dispersed Recreation:
There are three developed campgrounds within the analysis area, Tenderfoot, Granite Creek, and Bertha Creek Campgrounds. Tenderfoot Campground consists of a boat launch, one double pit toilet, one hand pump for potable water, and 27 individual campsites. Granite Creek Campground consists of one double pit toilet, one hand pump for potable water, and 18 individual campsites. Bertha Creek Campground is similar in nature with one double pit toilet, one hand pump for potable water, and 12 individual campsites. All of the campsites within all three campgrounds consist of a small spot for trailer/truck combination, as well as a picnic table and fire-ring for cooking. There are numerous areas of dispersed recreation within the analysis area. Primarily they are located along the Sixmile Creek as well as turnouts along both major highway systems and the Mills Creek road. State lands are also being impacted by dispersed use, especially under the Canyon Creek Bridge.

There are some opportunities for dispersed recreation along within the analysis area. People use pullouts and powerline access roads to get off the highway and picnic or camp. Some of the more popular sites for dispersed camping have an accumulation of toilet paper and human waste in the woods surrounding the sites. None of these sites have any developed sanitation facilities. Pullouts along Turnagain Arm and the Scenic Byway are popular scenic viewing and picnic locations. During summer months, many people including outfitter guide companies utilize the interior highways for day trips on mountain bikes.

Turnagain Pass:
The Turnagain Pass Winter Sports Area (Turnagain Pass WSA) is a very popular attraction for both summer and winter use. It is also a very popular and needed rest stop along State

Highway 1. The Glacier RD manages it, however it falls within this watershed analysis project area. In general the area is managed for hiking, sightseeing, wildlife viewing, berry picking and wild flower viewing during the summer months. There is limited off highway use utilizing some native material two-track roads, which are mostly user created. Very little long term camping occurs in this area during the summer, however it was observed that in the summer of 2002, there were quite a few recreational vehicles camping in the paved parking lot on the southeast side of the highway.

During the winter months, both cross country skiers and snowmachine users heavily utilize Turnagain Pass WSA. The north side of the highway is designated for motorized winter use and the south side of the highway is designated for cross-country and other non-motorized use. This differentiation seems to be working out very well. However the restroom facilities at this site are still in need of replacement.

Recreational Gold Panning:

The Sixmile Creek valley was the focus of intense placer mining activity during the Turnagain Arm Gold Rush in the late 1800's and early 1900's. The creek valley was also a transportation corridor to the community of Sunrise from the Johnson Military Road from Moose Pass and Seward. The mining activity is still evident within the analysis area and is limited to prospect pits and evidence of water diversion for use of hydraulic mining. Continued use of the area by people over the past 75 years has resulted in limited artifacts and other types of cultural features. Various cultural surveys have been done in the past 20 years in response to proposed project activities and placement of recreation facilities along Sixmile Creek. To a lesser extent most of the other streams that feed into the Sixmile Creek were also mined and they continue to produce some gold even today.

There is one recreational gold panning area within the analysis area. It is located along the western shore of Sixmile Creek between the Hope Highway turnoff and the community of Sunrise, along Forest Highway 14. The panning area starts at the southern boundary of Section 10 (where the creek enters the section), T.8N., R1W., and it terminates at the northern boundary of Section 22 (where the creek leaves the section), T.9N., R1W. Gold panning is only allowed on the western bank of the creek, and from the water line to below the water surface. No surface or stream bank disturbance is allowed.

Some conflicts have arisen in the past between recreational miners, mine claimants and the other river users over the issues of mining the banks, using wires across the river for mining access to the east side of Sixmile Creek, and general access to the river. A recreational mining plan was developed in 1996 for Resurrection Creek and Sixmile Creek to address these areas of conflict and to outline objectives for managing this use and for monitoring the resources.

Recreational Cabin:

There is one recreational cabin within the analysis area, and on state selected lands, which is the Manitoba Cabin. In the past this cabin was under a special use permit to a cross-country skiing permit holder, however that permit has expired and is not being renewed. There are on going plans to build a new cabin, in close proximity to the old cabin, which will be located on public lands. The old cabin will then be removed.

Wild & Scenic River:

Sixmile Creek is proposed for congressional designation as a Wild and Scenic River. Any management within the boundaries of this classified areas will need to meet the standards for viewsheds within the Wild and Scenic watershed corridor.

The tributaries of Sixmile Creek begin in Turnagain Pass, Summit Lake, and Johnson Pass and flow toward Turnagain Arm. In the lower reaches, Sixmile Creek quickly loses elevation flowing through steep canyons. It has reaches of placid water and reaches of class 4 and 5 rapids. For the past twenty years, white water rafters and kayakers have sought adventure in three main canyons of rapids which begin about 11 miles southwest of Turnagain Arm. Currently five outfitter guide companies are permitted through the Forest Service to guide commercially on Sixmile Creek. Many members of the public also use the river for floating in a variety of non-motorized watercraft. One of the permitted guiding companies has established an office in Sunrise where they run trips on Sixmile Creek.

Biannually a group called Knick Canoers and Kayakers from the Anchorage area arranges a Paddle Fest on Sixmile Creek. There are usually over 100 people that attend for a weekend of paddling and floating Sixmile Creek in the Boston Bar area of the creek.

Scenic Viewshed Driving:

There are two major transportation routes within the analysis area. They are State Highway 1 and Forest Highway 14, of which both are paved 2 and intermittent three lane highways.

State Highway 1 enters the analysis area in the Turnagain Pass WSA and exits the analysis area at the Summit Lake boundary. It bisects the analysis area and is approximately 29 miles in length. This highway has been identified as a National and a State Scenic Byway and it is one of only 15 highways nationwide that carries the highest distinction as an All

American Highway. Its scenic quality is unsurpassed and it is a major attraction for worldwide visitors. This includes, sightseers, Cruise Ship busses that transport passengers to and from Anchorage, winter & summer recreationists, as well as it being a major truck-hauling route. It is very important that whatever management activities may be planned within this view shed corridor, meet the proper ROS class and scenic byway standards.

State Highway 14 bisects the northern portion of the analysis area, is approximately 15 miles in length, and terminates at the community of Hope. It is a two-lane highway, utilized similarly, as is State Highway 1 but to a lesser extent. It accesses the only salt-water attraction on the Seward RD, which is Turnagain Arm. There are overlook areas along the highway, and within the analysis area, where Bore Tides (Bore Waves) and Beluga Whales can be sited. There is an ongoing small diameter vegetation removal project along Turnagain Arm, which the Seward RD and volunteers from the community of Hope are in partnership with. The vegetation removal project is removing all species of trees and brush, 5" DBH and less, in order to daylight areas along the highway of views of Turnagain Arm. Once the project is completed, the volunteers from the community of Hope will maintain the areas.

<u>Archaeology</u>:
The analysis area has both known and unknown archaeological resources. These resources will need to be protected and can be done so through project survey and mitigation. Non-project related archaeological surveys should be conducted to determine impacts to unknown sites from current recreational use. This however will likely not be funded due to current budget allocations and so individual project surveys will need to continue to occur.

<u>Iditarod NHT</u>:
The Seward RD is in its early stages of identifying new construction and reconstruction of the historic Iditarod Trail. The intention of this trail is to connect the communities of Seward and Girdwood, along a route that is as close as possible to the original trail location. There will be approximately six miles of new trail construction and nine miles of existing trail (Johnson Pass) reconstruction that will need to occur within the analysis area. It will be critical that any new trail locations, and the disturbance from them, will not impact the viewshed qualities along the Scenic Byway. Once the Iditarod NHT is established then general use of areas not currently utilized will greatly increase, at least along the trail and connecting trailheads and trail systems.

<u>Land Ownership</u>:

Most of the land within the analysis area is National Forest System Lands. The remaining lands are in private, state selected, and municipally owned.

There are numerous areas, within the analysis area, that are identified as being either “state-conveyed”, “state-may not be conveyed” and “state-probably will be conveyed”. The long-term ownership of how these lands will have an affect on the current recreational use as well as the overall future recreation experience. Some of these selected lands could have a long-term affect on access to public lands, especially in an area where dispersed recreation access is very limited. Also any development on these state lands (i.e. gas stations, restaurants, day use areas, campgrounds, boat launches, resorts, etc) could have an influence on increasing recreational use within isolated areas of the forest.

G. Subsistence

Early Resource Use

The Dena’ina people utilized available fauna and flora resources. Four species of salmon spawn in Six Mile/Canyon Creek watershed. Resident fish include: Dolly Varden, Arctic char, whitefish, lake trout, and rainbow trout. Salmon however provided the bulk of the diet. The Six Mile/Canyon Creek watershed has populations of moose, caribou, black and brown bears, Dall sheep, and mountain goats. Furbearers include: wolves, coyote, lynx, mink, land otter, marten, wolverine, fox, marmot, and beaver. Marine mammals such as beluga and harbor seal were harvested in Turnagain Arm. Sea cliffs between Hope and Sunrise overlook deep water where these mammals are frequently seen quite close to the shore and probably were sites of hunting for these animals.

Trading and bartering of resources were important activities for the early residents of Sunrise (Barry 1973). Trapping was and continues to be important to Sunrise residents. Moose, bear, and sheep were hunted (Knecht-Levine 1983). McCart (1983) refers to a moose hunt where dogsleds and snowshoes were the principal means of transportation and sharing or resources was prevalent.

Fish and game have been and continue to be very important to Sunrise residents. Moose were traditionally harvested in late October and November. Pink and King salmon were caught by nets and seines in Six Mile Creek. Pinks were mainly used as dog food.

H. Vegetation

A variety of plant community types occur throughout the assessment area, influenced by human and natural disturbances. Plant communities encompass a wide range of habitats, including coniferous forest, deciduous forest, mixed conifer/deciduous forest, dwarf tree forest, forest edges, tall shrublands, low shrublands, seeps and wet areas, riparian areas of various channel type, streambanks, waterfalls, lake margins, ponds, shallow freshwater, marshes, swamps, estuaries, sphagnum bogs, fens, heath, subalpine meadows, alpine tundra areas, dry to moist-wet meadows, grasslands, and even maritime beaches and tidal flats along Turnagain Arm. Forested habitats are generally spruce and hemlock, either mixed or pure stands, typical of the northern forest transition area from temperate coastal forest to boreal forests, interspersed with patches of hardwoods including birch, cottonwood, and some quaking aspen. Large patches of the forested portion are dead or dying spruce from the current spruce bark beetle infestation.

The assessment area includes nineteen consolidated cover types in the Chugach National Forest GIS database (see Table 1). These types, by largest acreage to smallest acreage with percentage, are grass and alpine (62,451/35%), rock (31,462/18%), other brush (24,838/14%), alder (14,129/8%), hemlock-spruce (13,060/7%), hemlock (12,706/7%), snow and ice (6770/4%), birch (3202/2%), mixed hardwood-softwood (2388/1%), water (915/1%), Sitka spruce (655), cottonwood (578), willow (532), other nonforested (491), muskeg meadow (241), non National Forest land (207), aspen (61), and nonstocked (5). The cover type layer in the GIS database was derived from a more detailed Timber Type layer, and several cover types reflect consolidations of these types according to the Chugach National Forest Resource Information Management Data Dictionary (2001). White spruce and Sitka spruce were combined to form the hemlock-spruce type. Mixed hardwood-softwood type includes aspen-white spruce, birch-white spruce, cottonwood-Sitka spruce, cottonwood-white spruce, cottonwood-birch-white spruce, aspen-hemlock, birch-Sitka spruce, and birch-hemlock. Cottonwood-balsam poplar (which are virtually the same species) was combined with cottonwood-birch to form cottonwood, aspen-birch and aspen were called aspen, and natural grass and alpine high meadow were combined to form grass and alpine. The original Timber Type layer was derived from aerial photo interpretation in the late 1960's and early 1970's. Additions and changes have been made to this layer as changes are noted on the ground, but the cover types listed polygon by polygon do not necessarily have complete accuracy.

Table 1 – All Cover Types	**Category**	**Acres**	**Percent**
GRASS AND ALPINE	Non Forested	62,451	35
ROCK	Non Forested	31,462	18
OTHER BRUSH	Non Forested	24,838	14

ALDER	Non Forested	14,129	8
HEMLOCK-SPRUCE	Forested	13,060	7
HEMLOCK	Forested	12,706	7
SNOW AND ICE	Non Forested	6,770	4
BIRCH	Forested	3,202	2
MIXED HARDWOOD-SOFTWOOD	Forested	2,388	1
WHITE SPRUCE	Forested	1,335	1
WATER	Non Forested	915	1
SITKA SPRUCE	Forested	655	0
COTTONWOOD	Forested	578	0
WILLOW	Non Forested	532	0
OTHER NON FORESTED	Non Forested	491	0
MUSKEG MEADOW	Non Forested	241	0
NON NATIONAL FOREST LAND	Non Forested	207	0
ASPEN	Forested	61	0
NONSTOCKED	Non Forested	5	0
		176,026	100

In Non Forested types, nonstocked refers to areas that currently do not have tree on them, but could support trees, such as a clearcut or other managed stand. Other brush generally refers to various shrub communities (DeVelice et. al. 1999) such as those dominated by salmonberry, dwarf birch, mountain-ash, and other tall shrubs.

One of the unique features of this watershed association area is the influence of elevation gradients on the distribution and type of vegetation. Vegetation above 1500 feet elevation is generally shrub and alder-dominated communities, including areas of dwarf birch, salmonberry, willow, various ericaceous shrubs and heath, mountain-ash, and others. Forested areas of conifers, hardwood, and mixed conifer/hardwood are confined to elevations below 1500 feet. Within the forested types, there are numerous interspersions of riparian areas, beaver ponds, floodplains, and alluvial terraces that support herbaceous graminoid types, shrub and low shrub types, forb communities, and even aquatic herbaceous types (DeVelice et. al. 1999).

The highest elevations support little or no vegetation and are covered with ice and snow, interspersed with bare rock and talus. In some areas in the higher elevation soils are more developed, supporting plant communities ranging from scrub heath and shrub to alpine grasslands and the colorful and unusual muskegs meadows, with acidic soil features and an unusual complement of ericaceous vegetation. Sideslopes at lower elevations support forested stands and wetlands spreading down to the alluvial valley bottoms of different watersheds. On steeper slopes and drainages, avalanches are a predominant force in vegetation dynamics.

CHAPTER 2-CURRENT AND REFERENCE CONDITIONS

For the purposes of this document, reference condition is described as prior to 1895. This time period is prior to most European settlement, and does not display the mining and trapping era's influence on the land. The reference condition still does include the human impact of indigenous people of the area however – notably the influence of human caused fire on the landscape.

This condition is sometimes erroneously referred to as being what the land might return to if all human impacts were eliminated. Dendrochronology studies and glacial analysis however have shown that climate was colder from the mid 1200's to mid 1800's (the time period called Little Ice Age), and a general warming period since then.

1. Historic/Social

A. Recreation/Subsistence

1. Before 1895

The time period associated with this Reference Conditions category is 1895. At that time there was no "recreation" use, as we know it today, occurring within the analysis area. However people were utilizing the area for mining, hunting, fishing, and activities associated with substance use and living off the land. These associated activities will need to be addressed under other categories other than Recreation.

Recreation, in the form of leisure time off of work, really did not occur until after World War II. Generally, nationwide and to some extent within the analysis area, the thought of camping, boating and fishing for fun, instead of for subsistence, became more and more popular after 1942. Sometime during the late 1940's to early 1950's the Granite Creek Recreation Area (current Granite Creek Campground) was established and possibly Bertha Creek Campground was established around the same time period. The Tenderfoot Campground came much later.

During the 1960's and 1970's, outdoor recreation expanded exponentially nationwide. South-central Alaska's population rose from 50,000 in 1950 to 110,000 in 1970, to

300,000 in 1985. Alaska residents sought recreation activities in a natural setting, while expanding tourism attracted many more visitors to Alaska. The Forest Service expanded and improved campgrounds, trails, and trailheads on the Seward Ranger District during the 1960's and 1970's in response to the increased public demand.

SUBSISTENCE IN THE SIX MILE/CANYON CREEK WATERSHED

Dena'ina Athabaskan Indians lived in Hope and Sunrise area in the 1800's and early 1900's. There were 2 communities, one near the present site of Hope and another to the west at Chickaloon Bay. Salmon runs, abundant game, and a variety of plant life were all important for the indigenous people.

In 1893, Charles Miller located the first claim on Resurrection Creek, 2 miles above the mouth. He leased the claim out to others for working and to quote Mary Barry "he made a good living for ten years and never hit a lick." Date not stated. This technique of mining miners repeats itself with the Hope Mining Company starting in the 1980's and continuing to this day. In 1893 Alex King staked a claim at Resurrection Creek. The following year, he was hanged in Dawson for murdering the pilot of a barge on the Yukon River. His significance was in spreading the word of his findings of gold in Turnagain Arm prior to his death (Barry 1973).

In nearby Bear Creek, George Beady and partners found gold in 1894. They claimed to have found artifacts of Russian mining on their claims. This gold discovery helped to initiate a gold rush in Six Mile/Canyon Creek watersheds the following year.

2. 1895 to Present

Sunrise is presently an unincorporated community with the Kenai Peninsula Borough. Tourism is an important component of the economy, with gift shops, recreation mining, restaurant, motel and store and cabin rentals as principal businesses. For some, Hope is a bedroom community for Anchorage and North Slope workers.

Use of large mammals within the watershed

The present harvest of large mammals is limited by regulation. Many of the hunts require permits. Because of these limitations and a reported reduction in populations, many local hunters no longer wish to harvest some species in the area (USFWS 1993). Wild resources continue to be important to Sunrise residents however (Seitz et al. 1992). For the residents of Sunrise and Hope in 1990, 20 large mammals were reported harvested (Seitz et al. 1992). The breakdown is as follows:

Black Bear 8
Caribou 8
Deer 2
Goat 1
Moose 6
Sheep 1

*the report does not indicate which animals came from Six Mile/Canyon Creek drainage.

Contemporary use of furbearers

The community usually has 2-3 regular trappers working the Six Mile/Canyon Creek watershed. Lynx, coyote, beaver, and mink are principal targeted species, with wolverine, wolf, marten, muskrat much less used (Spraker pers. comm.).

Contemporary use of other resources

Residents of Sunrise use many other forest resources in their subsistence lifestyle. Berry picking, mushroom gathering, burls for making bowls, and collecting birchbark are examples of special forest products which are readily available and extensively used. Species of berries which are heavily used include: raspberry, currents, watermelon berry, crowberry, lowbush and highbush cranberry, and blueberry. There are several other berry species which are more localized, and less intensively used. Bartering and sharing of processed products from these berries is commonplace (Mousley pers. comm.).

Other forest resources such as firewood and house logs are also regularly used by residents of Sunrise. The Forest Service office receives a high percentage of requests for these products from Sunrise.

RECREATION IN THE SIXMILE/CANYON CREEK WATERSHED

Recreationists utilize portions of the analysis area, with some areas being used more than others, and due to steep terrain some areas are utilized solely for scenery viewing. The used areas are in the form of hikers, backpackers, campers, recreational gold panners, bicyclists, horseback riders, hunters, fishermen, highway sightseers, cross-country skiers, recreation cabin users, and snowmachiners. These uses are generally restricted to a very limited area in direct association with the Johnson Pass, Summit Creek, and Gulch Creek Trails, rafting on the Sixmile Creek, the Tenderfoot, Granite Creek and Bertha Creek Campgrounds, as well as the popular Turnagain Pass Winter Sports Area, the Recreational Gold Panning area along the Sixmile Creek, recreation use at Manitoba Cabin, rafting of the Sixmile Creek, and scenic viewing/driving along State Highway 1 and Forest Highway 14. The analysis area also has unknown historic and prehistoric archaeological resources that will need to be protected. The Seward RD is also in the early stages of planning for the reconstruction and construction of the Iditarod National Historic Trail (Iditarod NHT), which will bisect the planning area with potential locations utilizing the Johnson Pass Trail and areas along State Highway 1.

<u>Trails</u>:
A portion of the Johnson Pass Trail is within the analysis area. There are approximately nine miles and one trailhead associated with this trail. A small portion of the Summit Creek Trail is within this analysis area. This consists of the trailhead and approximately ½ mile of the trail.

The Gulch Creek Trail was developed by miners to access claims up Gulch Creek. The trail begins on the north side of Sixmile Creek and climbs along the southwest side of Gulch Creek leading up the valley for approximately one mile. Old mining structures still used by claimants are located about one mile up Gulch Creek on the east side of Gulch Creek. There is a new bridge accessing the trail, which spans the East Fork Sixmile Creek, which was installed in the summer of 2002. A new trailhead is currently being considered for this trail.

The Sixmile Creek access trails have been developed over many years. Some have been brushed out recently to provide access to the creek below several rapids. These trails are used primarily by rafters (commercial and private) for scouting water levels and for ground support while rafts go through the rapids. Two of the trails are very steep and ropes have been put in place by outfitter guide companies to descend into the 3rd canyon.

There are also seven other lesser-identified trails within the planning area. These trails were previously identified and named in a historic document (Summit Lake Recreation Area, date unknown) located on the Seward Ranger District. They are identified as the Summit Lodge Trail, Fresno Mining Trail, Southeast Slope, Whitey’s Trail, Pass Creek Wedge, Frenchy Creek Area, and the Clinton Creek Shield. Many of these are believed to be only cross-country type of trails that can be accessed after significant snowfall, but are not physically established trails on-the-ground. It would be interesting to try to re-locate and/or reestablish these trails utilizing the descriptive locations identified in the above referenced document.

Campgrounds and Dispersed Recreation:
There are three developed campgrounds within the analysis area, Tenderfoot, Granite Creek, and Bertha Creek Campgrounds. Tenderfoot Campground consists of a boat launch, one double pit toilet, one hand pump for potable water, and 27 individual campsites. Granite Creek Campground consists of one double pit toilet, one hand pump for potable water, and 18 individual campsites. Bertha Creek Campground is similar in nature with one double pit toilet, one hand pump for potable water, and 12 individual campsites. All of the campsites within all three campgrounds consist of a small spot for trailer/truck combination, as well as a picnic table and fire-ring for cooking. There are numerous areas of dispersed recreation within the analysis area. Primarily they are located along the Sixmile Creek as well as turnouts along both major highway systems and the Mills Creek road. State lands are also being impacted by dispersed use, especially under the Canyon Creek Bridge.

There are some opportunities for dispersed recreation along within the analysis area. People use pullouts and powerline access roads to get off the highway and picnic or camp. Some of the more popular sites for dispersed camping have an accumulation of toilet paper and human waste in the woods surrounding the sites. None of these sites have any developed sanitation facilities. Pullouts along Turnagain Arm and the Scenic Byway are popular scenic viewing and picnic locations. During summer months, many people including outfitter guide companies utilize the interior highways for day trips on mountain bikes.

Turnagain Pass:
The Turnagain Pass Winter Sports Area (Turnagain Pass WSA) is a very popular attraction for both summer and winter use. It is also a very popular and needed rest stop along State Highway 1. The Glacier RD manages it, however it falls within this watershed analysis project area. In general the area is managed for hiking, sightseeing, wildlife viewing, berry picking and wild flower viewing during the summer months. There is limited off highway use utilizing some native material two-track roads, which are mostly user created. Very little long term camping occurs in this area during the summer, however it was observed that in the summer of 2002, there were quite a few recreational vehicles camping in the paved parking lot on the southeast side of the highway.

During the winter months, both cross country skiers and snowmachine users heavily utilize Turnagain Pass WSA. The north side of the highway is designated for motorized winter use and the south side of the highway is designated for cross-country and other non-motorized use. This differentiation seems to be working out very well. However the restroom facilities at this site are still in need of replacement.

Recreational Gold Panning:
The Sixmile Creek valley was the focus of intense placer mining activity during the Turnagain Arm Gold Rush in the late 1800's and early 1900's. The creek valley was also a transportation corridor to the community of Sunrise from the Johnson Military Road from Moose Pass and Seward. The mining activity is still evident within the analysis area and is limited to prospect pits and evidence of water diversion for use of hydraulic mining. Continued use of the area by people over the past 75 years has resulted in limited artifacts and other types of cultural features. Various cultural surveys have been done in the past 20 years in response to proposed project activities and placement of recreation facilities along Sixmile Creek. To a lesser extent most of the other streams that feed into the Sixmile Creek were also mined and they continue to produce some gold even today.

There is one recreational gold panning area within the analysis area. It is located along the western shore of Sixmile Creek between the Hope Highway turnoff and the community of Sunrise, along Forest Highway 14. The panning area starts at the southern boundary of Section 10 (where the creek enters the section), T.8N., R1W., and it terminates at the northern boundary of Section 22 (where the creek leaves the section), T.9N., R1W. Gold panning is only allowed on the western bank of the creek, and from the water line to below the water surface. No surface or stream bank disturbance is allowed.

Some conflicts have arisen in the past between recreational miners, mine claimants and the other river users over the issues of mining the banks, using wires across the river for mining access to the east side of Sixmile Creek, and general access to the river. A recreational mining plan was developed in 1996 for Resurrection Creek and Sixmile Creek to address these areas of conflict and to outline objectives for managing this use and for monitoring the resources.

Recreational Cabin:
There is one recreational cabin within the analysis area, and on state selected lands, which is the Manitoba Cabin. In the past this cabin was under a special use permit to a cross-country skiing permit holder, however that permit has expired and is not being renewed. There are on going plans to build a new cabin, in close proximity to the old cabin, which will be located on public lands. The old cabin will then be removed.

Wild & Scenic River:

Sixmile Creek is proposed for congressional designation as a Wild and Scenic River. Any management within the boundaries of this classified areas will need to meet the standards for view sheds within the Wild and Scenic watershed corridor.

The tributaries of Sixmile Creek begin in Turnagain Pass, Summit Lake, and Johnson Pass and flow toward Turnagain Arm. In the lower reaches, Sixmile Creek quickly loses elevation flowing through steep canyons. It has reaches of placid water and reaches of class 4 and 5 rapids. For the past twenty years, white water rafters and kayakers have sought adventure in three main canyons of rapids which begin about 11 miles southwest of Turnagain Arm. Currently five outfitter guide companies are permitted through the Forest Service to guide commercially on Sixmile Creek. Many members of the public also use the river for floating in a variety of non-motorized watercraft. One of the permitted guiding companies has established an office in Sunrise where they run trips on Sixmile Creek.

Biannually a group called Knick Canoers and Kayakers from the Anchorage area arranges a Paddle Fest on Sixmile Creek. There are usually over 100 people that attend for a weekend of paddling and floating Sixmile Creek in the Boston Bar area of the creek.

<u>Scenic Viewshed Driving</u>:
There are two major transportation routes within the analysis area. They are State Highway 1 and Forest Highway 14, of which both are paved 2 and intermittent three lane highways.

State Highway 1 enters the analysis area in the Turnagain Pass WSA and exits the analysis area at the Summit Lake boundary. It bisects the analysis area and is approximately 29 miles in length. This highway has been identified as a National and a State Scenic Byway and it is one of only 15 highways nationwide that carries the highest distinction as an All American Highway. Its scenic quality is unsurpassed and it is a major attraction for worldwide visitors. This includes, sightseers, Cruise Ship busses that transport passengers to and from Anchorage, winter & summer recreationists, as well as it being a major truck-hauling route. It is very important that whatever management activities may be planned within this view shed corridor, meet the proper ROS class and scenic byway standards.

State Highway 14 bisects the northern portion of the analysis area, is approximately 15 miles in length, and terminates at the community of Hope. It is a two-lane highway, utilized similarly, as is State Highway 1 but to a lesser extent. It accesses the only salt-water attraction on the Seward RD, which is Turnagain Arm. There are overlook areas along the highway, and within the analysis area, where Bore Tides (Bore Waves) and

Beluga Whales can be sited. There is an ongoing small diameter vegetation removal project along Turnagain Arm, which the Seward RD and volunteers from the community of Hope are in partnership with. The vegetation removal project is removing all species of trees and brush, 5" DBH and less, in order to daylight areas along the highway of views of Turnagain Arm. Once the project is completed, the volunteers from the community of Hope will maintain the areas.

B. Transportation System

People came to Sunrise by one of two means. At the turn of the century, ships were able to travel all the way up Turnagain Arm to Sunrise. Both cargo and passengers regularly diembarged from Sunrise. Since the 1964 earthquake however, water transportation has become much more difficult.

The land acess route was via trail which came from what was called Quartz Creek (now called Ingram Creek) to Granite Creek and down the miners trail (what later became the Moose Pass Military Road). This miners trail was first built in 1900 from Sunrise up to the Hope Y (where there was reportedly a hotel).

In 1902, Anton Eide contracted to haul mail between Sunrise and Hope to Resurrection Bay by dogsled. (Andy Simons later had this same contract). In 1907, a formal route was established from Seward to Nome, and traversing this watershed, called the Iditarod Trail. This route was used for transport of material to Nome and gold from Nome.

The Johnson Pass Military Road was constructed in 1907-1908 and came over Johnson Pass, down south side of East Fork and down the west side of Six Mile creek to Sunrise. In 1909, the transportation system was considerably improved when a wagon road was completed from Trail Lake to Hope.

Residents subsisted by mining, working as guides, trapping, selling moose meat, making snowshoes, and fishing and hunting (Knecht-Levine 1983).

Access improved in 1951 with the completion of the Seward Highway from Anchorage to Canyon Creek, near the Hope Y (Buzzell and McMahan 1986). Shortly thereafter, access was extended to Kenai. In 1969, electricity and telephones became available. In 1980, the Hope Highway was paved.

POPULATION CHANGES

By summer of 1896, the gold rush was in full force and Sunrise City began living up to its name as a city, and as the center of mining activity. By mid-May, an estimated 1500 people had landed and located on Six Mile Creek. Population at its peak 1896-1898. While the nearby town of Hope had a reported half of its 700 residents as Alaska Natives (Mishler 1985), there is no report of a similar diversity in Sunrise.

Population started dropping off - by 1907 there were 75 residents. By 1910 there were 35 people, dropping in 1911 to 12 people, only 2 people in 1930, and by 1939, it was deserted.

A. Recreation

Reference Conditions

The time period associated with this Reference Conditions category is 1895. At that time there was no “recreation” use, as we know it today, occurring within the analysis area. However people were utilizing the area for mining, hunting, fishing, and activities associated with substance use and living off the land. These associated activities will need to be addressed under other categories other than Recreation.

Recreation, in the form of leisure time off of work, really did not occur until after World War II. Generally, nationwide and to some extent within the analysis area, the thought of camping, boating and fishing for fun, instead of for subsistence, became more and more popular after 1942. Sometime during the late 1940’s to early 1950’s the Granite Creek Recreation Area (current Granite Creek Campground) was established and possibly Bertha Creek Campground was established around the same time period. The Tenderfoot Campground came much later.

During the 1960’s and 1970’s, outdoor recreation expanded exponentially nationwide. South-central Alaska’s population rose from 50,000 in 1950 to 110,000 in 1970, to 300,000 in 1985. Alaska residents sought recreation activities in a natural setting, while expanding tourism attracted many more visitors to Alaska. The Forest Service expanded and improved campgrounds, trails, and trailheads on the Seward Ranger District during the 1960’s and 1970’s in response to the increased public demand.

a. Hunting and Trapping

In 1990, the federal government assumed responsibility for the management of subsistence taking of wildlife and fish on federal public lands in Alaska. The Alaska National Interest Lands Conservation Act of 1980 requires that subsistence users have a priority over other users to take fish and wildlife on federal public lands where a recognized customary and traditional pattern of use exists.

With this change in management, the Federal Subsistence Board completed a process where subsistence (rural) communities were identified, and eligibility for subsistence was based on specific requirements regarding historic and contemporary uses of the resources. The entire Six Mile and Canyon Creek watersheds have been determined to be rural.

The community of Sunrise is the principal subsistence community within this watershed. The community of Hope is nearest other subsistence community, located to the west approximately 5 miles away.

C. Mining in the 6 Mile/Canyon Creeks Watershed

1. Gold Rush 1895 to present

Robert Michaelson's claims in Canyon Creek in 1895 appears to be the earliest mining in the Six Mile/Canyon Creek watershed. A schooner arrived in the Sunrise area, dropping off 20 prospectors which founded the town. According to Barry (1997) the town got its name from "This first group of settlers noticed that the morning sun appeared and disappeared behind the mountain peaks 3 times before climbing into full view, thus giving them 3 sunrises. In commemoration of this phenomenon, the place received the name Sunrise."

Ben Pilcher located the Last Chance claim on Six Mile Creek in 1895. By the end of the year, 45 claims were made on Six Mile Creek 45 on Canyon Creek and 18 on Mills Creek. Mining in the watershed was at its peak.

H.W. Scheffler made the first quartz location on the Kenai Peninsula on East Creek in 1895. In Mills Creek, near the intersection of Juneau Creek, Sam Mills, the recorder for the Sunrise Mining District attempted to locate a claim on this stream which now bears its name. While he failed to complete the filings, Robert Michaelson did, and found one of the peninsula's largest finds. His efforts, established as the Polly Mining Company yielded $40,000 that first summer. This find fueled the gold rush of 1896.

SIGNIFICANT MINING IN THE AREA

Claims on Lynx Creek were located by W.P. Powers and Fred Smith in 1896. Mining on this drainage was mostly by pick and shovel though hydraulic mining did take place in 1911.   Hydraulic mining took place in 1902 at the mouth of Bertha Creek (Vest Pocket Mine) and as late as 1970's (Discovery Group 1 through 10).

In 1898, another small stampede began when gold was found at Sniper's Point.

Sam Wible started hydraulic mining in the watershed in 1902 and was responsible for many of the ditches going from Canyon Creek to Lower Summit Lake.

Cub Creek also had a hydraulic plant in 1902. Mining slowed down by 1907, but picked up in 1909.

A forest fire in 1902 threatened Sunrise, burning hillsides and a few cabins.

In 1903, a copper mine began at the head of Lynx Creek. Active through 1907.

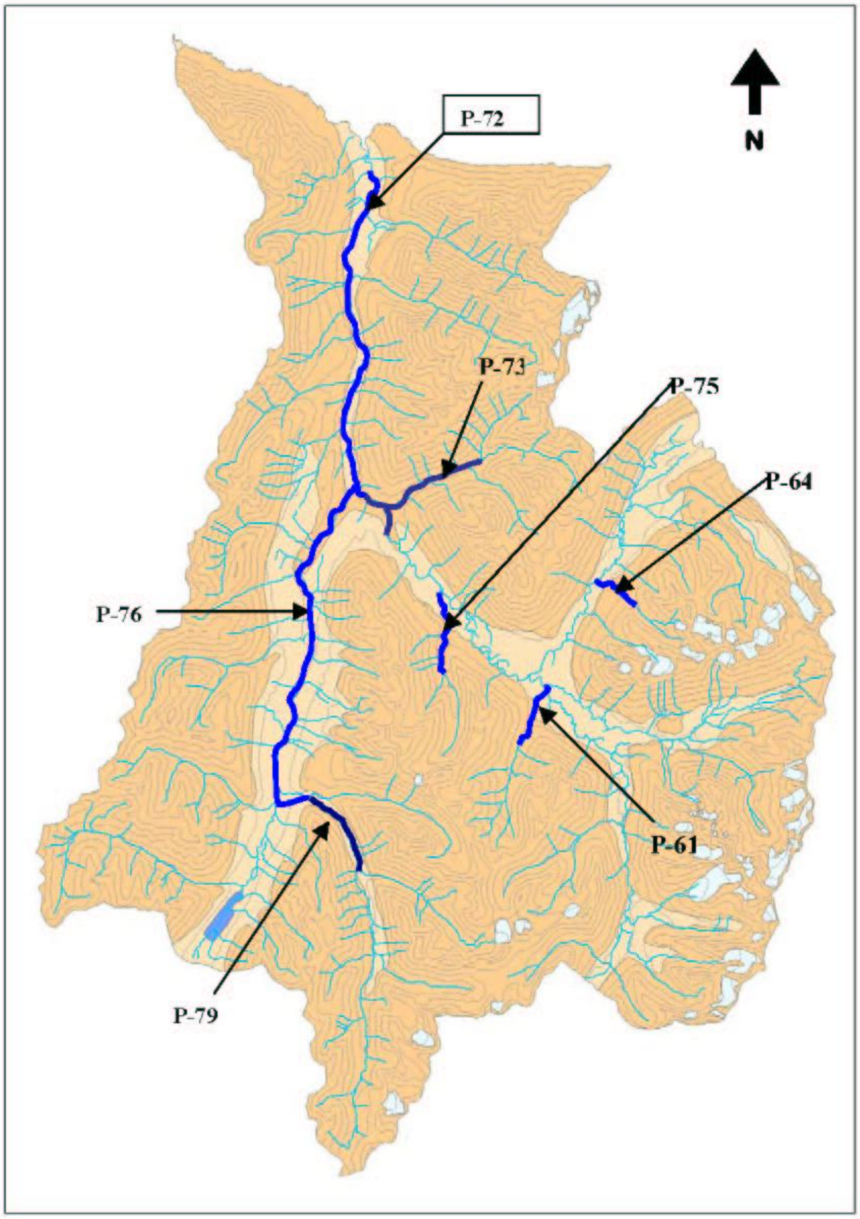
In 1915, a hydraulic mine was used in Canyon Creek.

A log dam was partially constructed on Canyon Creek above the Y from 1922 to 1925 when it was abandoned due to lack of funds. By that time it was 70 feet high (it was planned to be 110 feet high).

Current Mining

Placer Gold

Attachment 2 - Major placer deposits in the Sixmile/Canyon Creek Landscape Assessment Area



A. Geology and Deposit Types

Four types of placer gold deposits derived from gold-bearing quartz veins have developed within the assessment area as a result of glacial erosion, mass wasting, and fluvial processes: they are alluvial placers, bench placers, eluvial placers and glacial placers. Alluvial and bench deposits have produced the bulk of the placer gold.

Alluvial placers consist of gravel deposits resulting from the depositional and sorting processes of existing streams and include gravel bars, channel deposits, flood plain deposits and alluvial fans. Gravels tend to be sandy, poorly to moderately well sorted, and stratified but become increasingly consolidated and contain more clay near bedrock.

Bench placers consist of gravels deposited by streams at higher elevations within present valleys prior to the formation of the more deeply eroded active stream channels. Some of these deposits including abandoned channels were apparently deposited during interglacial periods prior to the most recent advance. Gravels tend to be poorly to moderately well stratified, poorly sorted, and moderately to well consolidated.
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There is a discussion of the general geomorphology and description of the placer deposits for each of the major placer producing streams in sections below.

B. Mining and Production History

Placer gold has been produced from a number of streams in the assessment area. Figure 5 shows the major historic producing streams. Attachment 2 is a map showing major placer deposits. These streams are still the focus of interest in placer gold mining in this area. Current placer mining consists primarily of suction dredging.

Figure 5. Major placer gold producing streams in the assessment area (Jansons and others, 1984)

Location	**Locality**[11]	**Gold production**[12] **(oz)**	**Est. auriferous gravels (cy)**
Canyon Creek	P-76	35,000 – 40,000	>2,000,000 (incl. lower Mills)
Lynx Creek	P-61	6,000 – 8,000	>1,500,000
Mills Creek	P-79	3,000 - 5,000	See Canyon Creek est.
Gulch Creek	P-73	1,000 – 2.500	Limited quantity of gravel
Sixmile	P-72	1,500 – 2,000	>5,000,000

[11] Locality numbers "P-72" etc. are shown on Attachment 1 – Major Placer Deposits of the Canyon-East Fork Creek Assessment Area.
[12] Estimated

Creek			
Bertha Creek	P-64	300 - 600	Limited quantity of gravel
Silvertip Creek	P-75	750 – 1,000	>1,000,000

Considerable surface disturbance occurred during the gold rush period, primarily on the major placer streams. Most of the surface disturbance on these streams occurred during hydraulic mining. Since the 1950s, suction dredging[13] has replaced hydraulic mining as the primary mechanized method. Attachment 2 shows the major placer producing streams in the assessment area; they are discussed in detail, below. There is a discussion of the general geomorphology, description of the placer deposits, brief mining history, Bureau of Mines RARE II[14] sampling results, estimated placer gravels, and estimated production.

C. Major Placer Streams

a. Canyon Creek and lower Mills Creek (P-76).

Canyon Creek is about 8 miles long and occupies a narrow bedrock canyon that is cut deeply into a broader U-shaped glacial valley. The canyon ranges from 100 to 200 feet or more deep and extends from a point just below the Canyon Creek bridge (Seward Highway), to a point just below Mills Creek. Above Mills Creek the valley is open and the stream has not cut deeply into the gravels. Bedrock consisting of interbedded slate and greywacke strikes nearly parallel to the stream.

Placer gold occurs in alluvial gravels in the current channel and in bench gravels at elevations up to at least 100 feet above the present stream level (Jansons and others, 1984). Much of the bench gravel is rounded and well stratified; this is shown in gravel near the "forks[15]". In places, gravel is compacted and cemented by iron oxide and contains considerable clay. Fine gold is distributed throughout the gravel but the best grade is on bedrock. High bench gravels on the edge of the canyon, some 3 miles above the forks have been mined. Channel gravels are low in volume but reported to be high grade. Martin and others (1915) reported that the channel gravels were by far the most productive. The swift current prevents uniform distribution of gold but the eddies behind large boulders have resulted in the deposition of rich pockets of gold. These spots lend themselves to "sniping" and have been worked by hand means and recently by suction

[13] The suction dredge is a floating, self-contained motorized piece of equipment that has a long hose with a nozzle on the end to suck up gravels from the streambed and eject them across a small sluice box. The waste gravel flows off the end of the sluice and the gold is retained in the sluice. This produces a concentrate.

[14] Roadless Area Review and Evaluation (RARE II) was conducted from 1979 to 1983. The Bureau of Mines investigated mine, prospects and mineral occurrences on the Chugach National Forest.

[15] Juncture of East Fork, Sixmile and Canyon Creeks.

dredging. Canyon Creek gold is generally coarse, as would be expected from the nature of the channel and swift current; gold from the forks is finer. Gold is flaky and recovery of particles up to 3/16 inch considered common.

High bench gravels on the edge of the canyon, some 3 miles above the forks have been mined. Channel gravels are low in volume but reported to be of high grade. Martin and others (1915) reported that the channel gravels were by far the most productive. Because of the swift water and the narrow channel, mining has been difficult on Canyon Creek. Never-the-less, considerable hand placer and hydraulic placer mining has occurred, especially at its junction with Mills Creek, between 1895 and 1940. The majority of the gold production took place between 1896 and 1920. The more extensive operations always involved the construction of wing dams to confine the water to one side of the channel while the other side was being worked out. Paige and Knoph (1907) visited Canyon Creek in 1906, a season in which some 50,000 cubic yards of gravel were moved by hydraulic methods. In 1911, as in previous years, hydraulic operation were continued on these bench gravels, nearly working out the rock-cut channel referred to by Moffit (1906), a channel about 650 feet long, 100 feet wide and 30 feet deep, crossing a nose in the bedrock 150 feet above the present level of the channel. Considerable work was also done near the mouth of Pass Creek (Martin, 1915). Several small mechanized and hydraulic operations have mined intermittently during 1955 – 1961 and in 1977 – 1978 (Jansons and others, 1984).

Mills Creek has yielded more gold than any other stream of the Turnagain Arm field except Canyon Creek. The important known gold-bearing gravels extend only from the mouth of the creek to the mouth of Juneau Creek, a distance of about ¾ mile. Moffit (1905) reported that in 1904 the canyon of Mills Creek had been once worked over, but that there still remained small areas, at least, sufficiently rich to pay for sluicing. Martin and others (1915) reported that a hydraulic outfit using two giants, a No. 1 and a No. 2 piped off a small, low bench about 15 feet above the creek level. This operation occurred a short distance above the junction with Canyon Creek and employed four men for part of the season. Operations were discontinued in late August, when the water supply from Moose Creek became insufficient for hydraulicing. The U.S. Bureau of Mines estimated production between 35,000 to 40,000 ounces of gold since 1895. This figure includes Mills Creek below Juneau Creek.

b. Lynx Creek (P-61)

Lynx Creek is about 3 miles long and occupies a steep narrow canyon cut into glacial till, poorly washed glacial–fluvial gravels, and bedrock. A well-developed alluvial fan has formed between the canyon mouth and its junction with Bench Creek. Terraces mantled with avalanche debris extend along most of the creek. The auriferous bench deposits consist of poorly stratified and washed, partially cemented gravels greater than 15 feet thick, resting on bedrock. The alluvial fan consists of well-stratified and washed gravels containing fine-grained particles of disseminated gold near the surface.

Pick and shovel operations occurred between 1897 and 1904. Hydraulic operations began in 1915 and mined bench deposits sporadically until 1980 (Jansons and others, 1984).

In the early 1980s the U.S. Bureau of Mines collected 14 placer samples from Lynx Creek. Four 3-inch suction dredge samples yielded 0.001 to 0.0149 oz of gold per hour. Seven 0.7 cubic yard bench samples contained 0.0013 to 0.074 ounces of gold per cubic yard. Inferred reserves at one test location were estimated at 5,000 cy with a grade of 0.015 to 0.02 oz per cy. The alluvial fan contains in excess of 1.5 million cy of gravel. The U.S. Bureau of Mines estimated production between 6,000 to 8,000 ounces of gold since 1897.

c. Mills Creek (P- 79)

Mills Creek is nearly 5 miles long, but the important known gold-bearing gravels extend only about three-quarters of a mile, from the mouth of the creek to the mouth of Juneau Creek (P-76). Along this section the channel flows along the contact of the gravels and bedrock, producing a canyon whose south wall is chiefly rock and whose north wall is chiefly gravel. The channel is cut principally in gravels. The upper portion of Mills Creek lies in a U-shaped glacial valley covered with gravel. There are high benches near the mouth of Juneau Creek, which form the north wall of the canyon below that point. Minor bench gravels are present in the upper valley.

Hydraulic operation began in Mills Creek, about ½ mile above Juneau Creek in 1938. One hydraulic or small mechanized operation has mined intermittently since that time (Jansons and others, 1984).

The U.S. Bureau of Mines collected 10 placer samples from Mills Creek. Seven of these were collected below the junction of Timberline Creek. The 4 bench samples contained from a trace to 0.0044 oz gold per cy. A suction dredge sample yielded 0.0554 oz gold per hour. Two stream channel samples contained 0.0011 and 0.0869 oz of gold per cy. Three suction dredge samples above Timberline Creek yielded from 0.0005 to 0.0012 oz of gold per hour. Below Timberline Creek bench deposits are estimated to be greater than 0.5 million cy and unworked channel gravels are estimated to range from 50,000 to 150,000 cy. Estimated production is between 3,000 to 5,000 ounces of gold, however no records are available to verify these amounts (Jansons and others, 1984).

d. Gulch Creek and lower East Fork Creek (P-73)

Gulch Creek is a small stream joining East Fork 1 mile above the mouth of Canyon Creek. East Fork is the larger of the two branches of Sixmile Creek. Gulch and lower East Fork

Creeks occupy narrow bedrock canyons along most of their length and contain thin, discontinuous high-grade gravel deposits. At least one abandoned channel on Gulch Creek was mined in the early 1900’s and others may occur along lower Gulch Creek and East Fork Creek. Channel gravels range from loose and sandy on the surface to clay-cemented with boulders as much as 5 feet in diameter or more on bedrock. Fine-grained gold is disseminated throughout the gravel but the pay streak occurs on bedrock and in bedrock fractures accompanied by sticky tan clay. Relatively coarse gold, up to 5-ounce nuggets, have reportedly been recovered from Gulch Creek.

East Fork Creek carries a larger body of water than Canyon Creek and the difficulties in handling gravels are the same. Martin and others (1915) reported that wing dams are always necessary. Prior to 1917, most of the production on lower Gulch Creek and on the east side of East Fork Creek was by hydraulic and hand operations.

The U.S. Bureau of Mines collected three suction dredge samples from the headwaters of Gulch Creek, which yielded 0.0006 to 0.0034 oz of gold per hour. Another two samples collected form upper Gulch Creek contained from 0.0008 to 0.0296 oz gold per cy. Nine placer samples were collected from within the canyon of lower East Fork Creek; they contained form 0.0019 to 0.015 oz of gold per cy. The quantity of gravel is limited. Estimated production is between 1,000 to 2,500 ounces of gold since 1897.

e. Sixmile Creek below Canyon Creek (P-72).

The union of East Fork and Canyon Creeks forms Sixmile Creek; it drains an area of approximately 250 square miles. It is about 10 miles long and occupies a relatively broad alluvial filled valley with periodic development of bedrock canyons along its channel. Alluvial terraces partially covered with avalanche debris, parallel the stream channel. Gold is relatively fine in size; nuggets coarser than ¼ inch are rarely recovered. Flood plain deposits appear to be relatively thick with depths to bedrock greater than 70 feet reported near the junction with Canyon Creek. Small auriferous alluvial fan deposits are associated with several western tributaries of Sixmile Creek; these include Alder Creek, Cub Creek and Old Woman Creek.

Several small operations produced gold from Sixmile Creek between 1897 and 1917. Prospecting, drilling, and limited hydraulic mining occurred in the 1930s. In the early 1980s the gravels just below Canyon Creek were tested by backhoe and 12-inch suction dredge. The results are unknown.

In the early 1980s, the U.S. Bureau of Mines collected samples from Sixmile Creek and several tributaries. A 0.1 cy sample from Alder Creek contained 0.0017 oz gold per cy: one from Cub Creek contained 0.0073 oz of gold per cy. From the stream channel, two suction dredge samples yielded 0.002 and 0.0182 oz of gold per hour, and one pan sample taken on bedrock contained 0.0214 oz gold per cy. Three bench samples contained 0.0005 to 0.0028 oz gold per cy. Bench gravels and channel volumes are estimated to be greater than 5 million cy. Production since 1897 is estimated between 1,500 to 2,000 ounces of gold.

f. Bertha Creek (P-64).

Bertha Creek is about 2 ½ miles long and flows into Granite Creek. It occupies a U-shaped valley in its upper portion and a steep narrow canyon cut mostly in glacial debris and bedrock in its middle section. Below the canyon an alluvial fan has been deposited which has been the major source of gold produced. Gravels are poorly to moderately stratified with a high clay and boulder content. Gold is concentrated on or near bedrock.

Hand placer and hydraulic mining occurred between 1902 and 1904. The U.S. Bureau of Mines collected three samples from lower Bertha Creek. A dredge sample yielded 0.0142 oz of gold per hour, bedrock was not reached. Two bench samples contained 0.0006 and 0.0129 oz of gold per cy. Traces of gold were recovered form surface gravels on upper Bertha Creek. Quantities of gravel are limited. Production since 1902 is estimated to be between 300 to 600 ounces of gold.

g. Silvertip Creek (P-75).

Silvertip Creek is nearly 4 miles long and flows into East Fork Creek. The upper portion of the creek occupies a steep narrow bedrock canyon partially filled with avalanche debris. The lower sections occupy a slightly wider channel with bedrock near the surface covered by poorly washed and stratified clay-rich gravels containing gold. The lower-most section occupies an alluvial fan consisting of moderately well stratified and washed gravels that have historically supplied fill for construction of the Seward Highway.

Pick and shovel operations occurred between 1897 and 1904. A small hydraulic operation was attempted in 1911. Small mechanized operations have mined sporadically since 1950 and suction dredges since 1975.

The U.S. Bureau of Mines collected one sample from Silvertip Creek, which contained 0.0019 oz of gold per ton (Jansons and others, 1984). They indicated that the alluvial fan should be tested since it contains significant quantities of gravel. Total estimated production is between 750 to 1,000 ounces of gold.

D. Minor placer gold streams

Within the assessment area several streams in the Turnagain Pass are known to be auriferous, zero to minor production has occurred. These are Spokan, Lyon, Peters, and Tincan Creeks. No significant production has occurred on East Fork Creek above Gulch Creek and Granite Creek to Tincan Creek. Some evidence of suction dredging and hand placering exists in the junction area of Groundhog Creek including ½ mile of Bench Creek below Groundhog Creek. In the 1950s, a single hydraulic operation mined the bench deposit at Juneau Creek above Mills Creek. No production records are available. Fresno Creek contains fine-grained gold that is sparsely disseminated throughout the poorly washed gravels. Colorado Creek was mined by a mechanized operation between 1977 and 1982 with little success. Estimated production is less than 50 ounces of gold.

E. Current Mining

Placer gold is being mined at a "hobby" level. This means that no full-time mechanized mining is occurring. Hobby level is part-time generally summer mining. The phrase "hobby mining" implies that the "miner" has employment other than mining as his primary support. Hobby mining in the assessment area consists primarily of small-scale suction dredging in the active stream channel. The 4- to 5-inch (nozzle size) suction dredge is popular; one person can operate it. Additionally, the 4-inch nozzle size falls under what the Forest has designated as "recreational size". Therefore, if the dredge is operated within the flowing waters of the stream, no notice of intent or plan of operations is required.

Some hand placer work is being done. This is also "hobby" or "recreational" in scope. Hand placering is done on a seasonal and part-time basis. Hand placering is primarily accomplished by the operator shoveling gravels into a sluice box, with water flowing through to wash the material. Along with the water, gravel flows out the end of the sluice box and the gold is trapped behind the riffles.

Panning is most generally done to extract gold from the sluice concentrates. Panning is also an exploration tool, used to determine the presence of gold in stream or bench gravels.

Copper Deposits

A. Geology

Sedimentary rock hosted copper occurs within the assessment area, near the headwaters of Lynx Creek. The occurrence is small and the grade is medium; the average copper content from 8 samples was 2.5% (Jansons and others, 1984). The mineralization occurs along a well-developed shear zone, 3- to 10-foot wide over an exposed strike length of approximately 110 feet. Within this zone is a 1- to 4-foot thick and as much as 40-foot-long podiform masses of massive sulfide ore containing chalcopyrite, arsenopyrite, pyrrhotite, and minor galena. The vein appears to be truncated at both ends by transverse faults topographically expressed as gullies. The Ready Bullion (S-272) prospect is the only example of this deposit type in the assessment area and in the Kenai Peninsula; there has been no production from this site.

B. Mining and Production History

Small nuggets of native copper were found on Lynx Creek in the sluice boxes of early placer miners. This lead to the discovery of a copper lode near the headwaters of Lynx Creek. Development work was carried on at the Ready Bullion prospect (S-272) in 1905 and 1906 by the Ready Bullion Copper Company (Martin and others, 1915). At 3,000 feet elevation, they drove a 350-foot-long adit, and then drifted another 240 feet along a shear zone. About 1,000 feet below the first adit, they drove another adit for 800 feet to intercept the ore zone, but they failed to intercept it. The workings totaled 1,390 feet of adit and drift. Work was discontinued in October 1906. Except for a short adit, 20 to 25 feet in length that was driven in the canyon of Lynx Creek on an outcrop showing narrow veins of chalcopyrite, no further development work has been done. A small prospect pit is present above the upper adit.

An overgrown access road begins at Johnson Pass Trailhead, crosses Center and Bench Creeks and continues up Lynx Creek to the ruins of the old Ready Bullion mining camp. It is located at 1,700 feet of elevation, at the stream level.

C. Current Mining

The Ready Bullion copper prospect (S-272) occurs within the assessment area. The U.S. Bureau of Mines sampled it in 1982-3; average copper grade was 2.5% (Jansons and others, 1984). They estimated reserves of 6,000 tons. The most recent development work was done in 1906. There is no current operation either producing or developing the copper deposit. Based on limited reserves, depressed copper prices, and the lack of any industry interest over the years, the potential for development or production is low.

Sand, Gravel and Rock

A. Geology

a. Sand and Gravel

Quaternary-age surficial deposits consisting of sand and gravel occur along the major streams in the assessment area. Considerable use has been made of these deposits, especially along the Seward Highway between Granite Creek campground north to and including the Silvertip pit (Attachment 3), mostly for road construction. A mineral material survey was done by the Bureau of Land Management (BLM) assisted by Carol S. Huber, Forest Geologist in 1996 for the Forest Service (Sherman and others, 1997). They identified and sampled several old gravel pits. A limiting factor for developing most of the pits along East Fork Creek is the high water table. BLM sampled these old pits (Attachments 4 and 5), and had lab analysis done (Figure 6) on all except the Johnson Pass trailhead material. Two tests were done on selected samples: the L. A. abrasion (T-96) and degradation (T-13). The cutoff values[16] for the L.A. abrasion test are 45 for asphalt and 50 for base; the minimum degradation value is 30 for base course is 45. Lower L.A. abrasion values are more desirable, but higher degradation values are more desirable.

Site	Sample #	L.A. Abrasion	Degradation
Bear Pit - west	IM046	38	19
Bear Pit – access road	IM048	33	20
East Fork - exploration pit	IM029	33	28
East Fork - woods	IM030	34	12
Fly Pit - east cut bank	IM035	35	24
Fly Pit – East logging road	IM058	36	18
Silvertip pit - east	IM042	25	**25**
Silvertip pit South Gully	IM043	23	23

Figure 6. Quality tests on selected sand and gravel samples from the mineral materials study (Sherman and others, 1997)

In addition to the known deposits, BLM also surveyed the Seward and Sterling Highway corridors for new sources. They identified a high potential source, which they called Canyon Creek headwaters, located at the base of the mountain between Canyon and Quartz Creeks, just outside of the south boundary of the assessment area. They did not however, identify any new sources within the assessment area.

b. Rock

The assessment area rock types are common variety graywacke and slate. Some of the graywacke is suitable as rip rap and other construction purposes, and some of the slate is suitable for decorative building stone uses such as fireplace facing, walkways, flowerbed borders and the like. A narrow felsic dike (Gilpatrick Dike) that trends roughly northward and generally parallels Canyon Creek, intrudes slate and greywacke country rock in the assessment area. This rock has not been used for either construction or building stone. A mineral material survey was done by the Bureau of Land Management assisted by Carol S. Huber, Forest Geologist, in 1996 for the Forest Service (Sherman and others, 1997), which sampled several known rock sources and potential rock sources. They tested the quality of the greywacke rock for road construction purposes. The results of these samples are shown below in Figure 7. The L.A. abrasion and degradation tests are explained under the

[16] Based on DOT requirements from Standard Specifications for Highway Construction, 1988.

section above, d. Sand and Gravel. The maximum value of the soundness test is 9, for asphalt. Two of the samples below meet the cutoff values for all 3 tests for asphalt and base course. The North Granite Creek Road rock does not meet the minimum degradation value of 45 for base course but it does meet the minimum degradation value of 30 for asphalt; it also meets the L.A. abrasion specifications for both base course and asphalt.

Site	Sample	L.A. Abrasion	Degradation	Soundness
North Granite Creek Road	IM041	21	37	0.5
Silvertip Creek Quarry	IM040	18	71	1.5
Silvertip Creek Quarry talus	IM029	22	51	0.9

Figure 7. Quality tests on selected rock samples from the mineral materials study (Sherman and others, 1997)

Specific rock deposits are discussed in detail below. Attachment 3 shows the location of the Silvertip Creek quarry and Attachment 4 contains site maps for the North Granite Creek Timber Road rock source and Silvertip Creek quarry.

B. History

Common variety sand, gravel and rock has been mined historically from a number of locations in the assessment area and used locally for road construction and reconstruction. Materials sites are identified under the Mineral Deposits section of this report. Several additional old pits that not shown in the Minerals Deposits section are shown on the 1:63,360 scale USGS topographic maps, specifically Seward C-7, D-7, and D-6 maps. Little to no information is available about these sites. A slate source at mile 2, Hope Highway has been used locally as a decorative building stone for many years, probably since the Hope Highway was constructed. This slate is not of sufficient quality to warrant marketing it out of the local area. The Silvertip Quarry, on State land, is a good source for riprap and has likely been used for many years, probably since the highway was constructed. The Silvertip Creek quarry on Federal land is similar in quality and probably in history of use to the Silvertip quarry.

During the 1980s the U.S. Bureau of Mines published a series of reports in conjunction with the U.S. Forest Service Roadless Area Review and Evaluation II (RARE II) study. No specific work was done on mineral materials; however, aggregate resources were identified as a result of the placer mine investigations. At the same time the USGS was conducting Alaska Mineral Resource Appraisal Program studies of the region which included geologic mapping (Nelson and others, 1985) and identification of alluvial sources for aggregates as part of a mineral resource potential study of the Chugach National Forest (Nelson, 1984).

Mineral Materials Sources

a. Sand and Gravel

1. Bear Pit (2[17]).

This site consists of approximately 27 acres on the north side of the Seward Highway across from the active East Fork pit. The material varies across the site due to the influence of the talus/avalanche slope at the base of the mountain. Generally, the material is subangular to rounded sandy gravel with moderate to poor sorting.

ADOT dug 29 test pits in 1986 and an additional 10 pits in 1993. Sample results indicated that of the 15 samples tested, only 3 exceeded the minimum degradation value of 45 for aggregate for base course. Ten of the 15 samples exceeded the minimum degradation value of 30 for aggregate for pavement.

In 1996, BLM collected 6 samples that they screened and did a sieve analysis on. They subjected 2 of these samples to lab analysis; results are in Figure 5.

2. East Fork Pit (5)

This is an active pit that has been in use by ADOT for a number of years. It is located south of the Seward Highway, between Granite and East Fork Creeks (between Mile 61.9 and 62.3). The material consists of sandy gravel that is generally rounded to subangular. The material is usually moderately well sorted, although some poorly sorted material exists. The silt/clay size fraction tends to be high in some samples. Some of the cobbles exhibit a high degree of weathering and exfoliation.

In 1986, 38 test pits ranging in depth from 4.5 to 13 feet were excavated by ADOT. An additional 17 pits were dug in 1993, with depths ranging from 12 to 19.5 feet. The water table is shallow in the pit area, varying from 4 to 12.5 feet below the surface. Analysis of the samples by ADOT revealed that only 4 of 16 tested passed the minimum degradation value of 45 for base course and only 8 passed the minimum of 30 for aggregate for pavement. [18] Despite the relatively poor sample results, the pit has been extensively used.

In 1996, BLM collected 5 samples that they screened on site and performed a sieve analysis on. No samples were taken in the existing pit area. Instead, samples were concentrated in an area where further expansion might be possible. They subjected 2 of these samples to lab analysis; results are in Figure 6.

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[17] Number is identifier from Sherman and others, 1997 report.
[18] Information from Material Site Summary, Alaska Dept. of Transportation files

3. Fly Pit (7).

The site is located just west of the Granite Creek campground road, on the south side of the Seward Highway. It consists of two sections: an older mined-out section that has been left to revegetate (west end) and a newer section (east end) where waste material from recent construction projects appears to have been dumped. The material in the old pit area consists of poorly sorted subangular to rounded silty/sandy gravel. The material sampled in the east pit consisted of moderately well sorted to poorly sorted silty/sandy gravel that is subangular to subrounded in shape.

In 1996, the BLM collect 4 samples that they screened on site and did a sieve analysis for. They subjected 2 of these samples to lab analysis; results are in Figure 6.

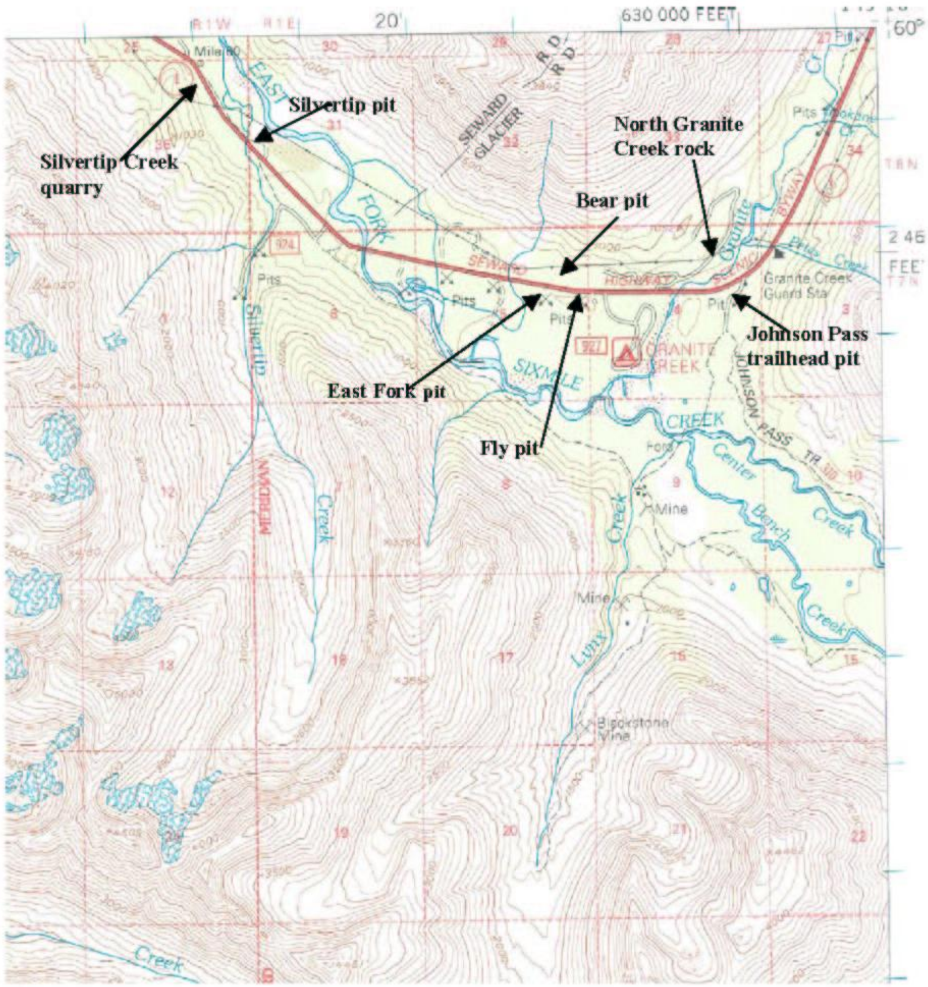
4. Johnson Pass Trailhead Road (13).

The site is located next to the road leading to the Johnson Pass trailhead between Petes Creek and Granite Creek. There is evidence of a former shallow pit that was likely used in construction/modification of the Seward Highway or the trailhead road itself. The BLM did a brief examination of the area in 1996 to determine if it warranted sampling. The material noted on the east side contained a fair amount of angular to subangular cobbles, indicating the influence of avalanche debris or talus slope material. They did not collect any samples.

5. Silvertip Pit (21).

The site is located on the north side of the Seward Highway, just east of Silvertip Creek. This site has been used extensively in the past. Recently the pit has been used to dump shot rock, topsoil, and stumps. The material varies across the area, although it appears to transition from alluvial gravels in the western end to glacial till in the eastern end. Test holes dug in the bench to the east revealed glacial till with a high silt/clay size fraction. In general the material is poorly sorted and rounded to subangular. In 1996, the BLM collected 2 samples for screening and sieve analysis; both samples were submitted for lab analysis. The results are shown in Figure 6.

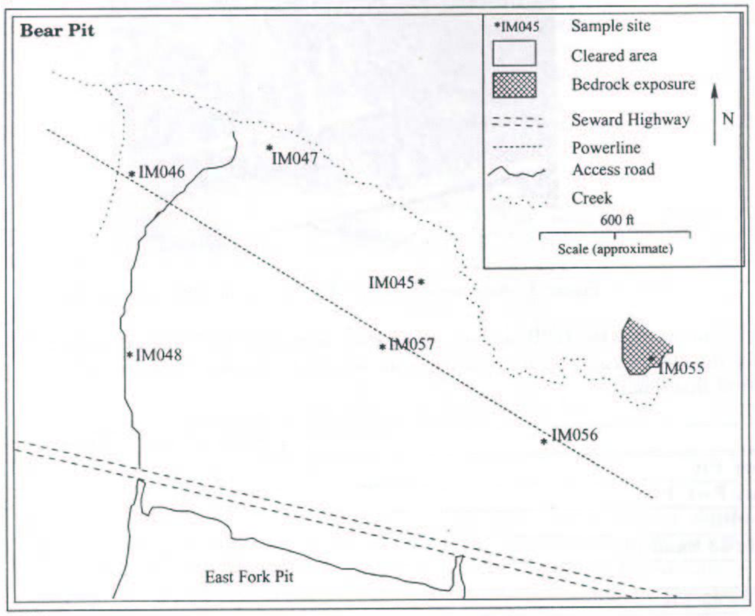
Attachment 3. Mineral Materials Sources, Canyon Creek/ Six Mile Creek Landscape Assessment Area



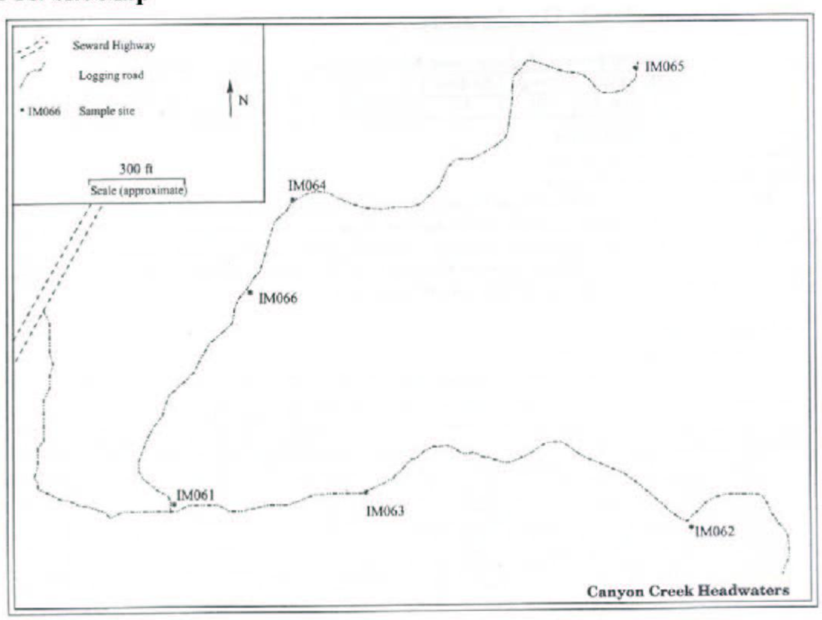
- Slate rocks source along the Hope Highway (mile 2 and 4) are not shown.
- Mineral Materals sites on state or state selected lands are on Attachment 6.
- Site names are from Sherman and others, 1997.

Attachment 4. Mineral Materials site maps, Sixmile/Canyon Landscape Assessment Area

From Sherman and others, 1997



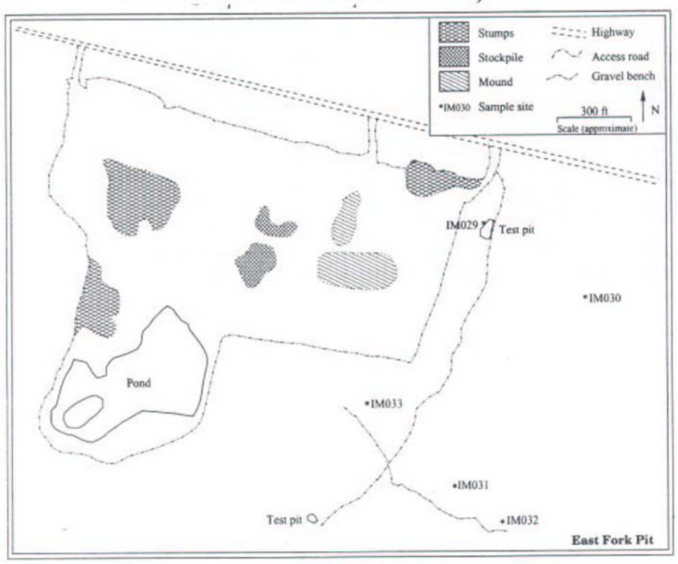
Bear Pit Site Map



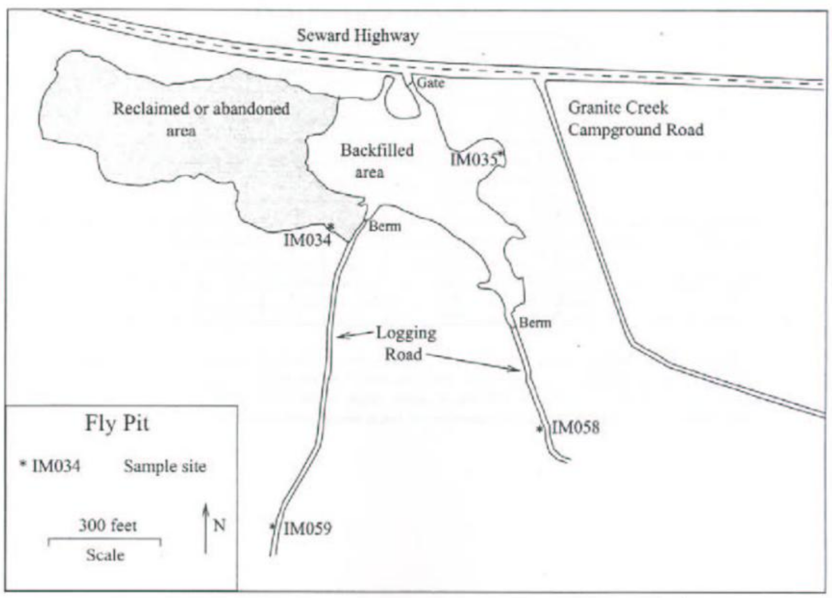
Canyon Creek Headwaters Potential Sand and Gravel Source Site Map

Attachment 4. Mineral Materials site maps, Sixmile/Canyon Landscape Assessment Area

From Sherman and others, 1997



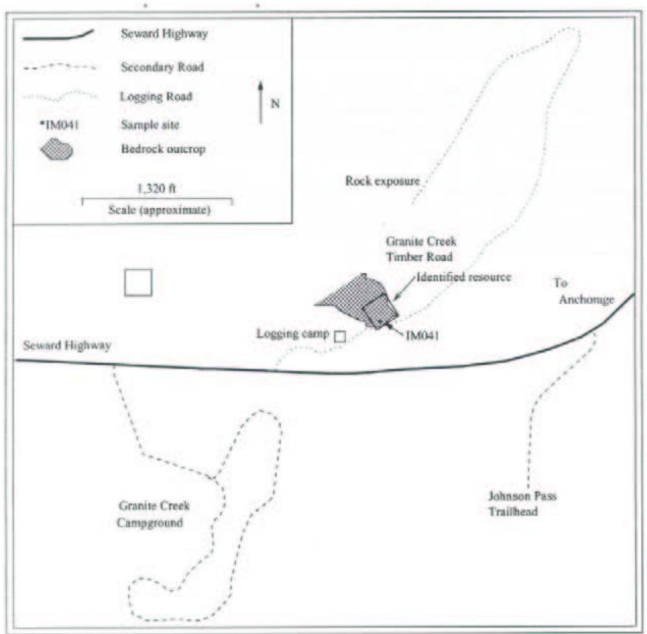
East Fork Pit Site Map



Granite Creek Campground Pit (Fly Pit) Site Map

Attachment 4. Mineral Materials site maps, Sixmile/Canyon Landscape Assessment Area

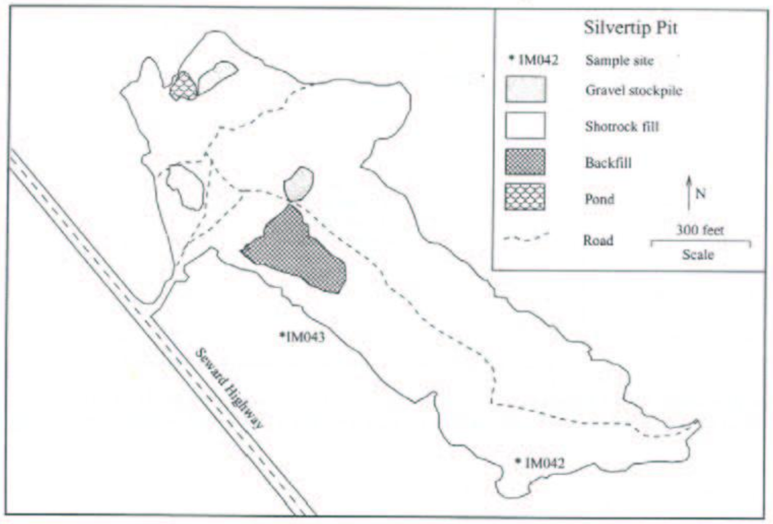
From Sherman and others, 1997



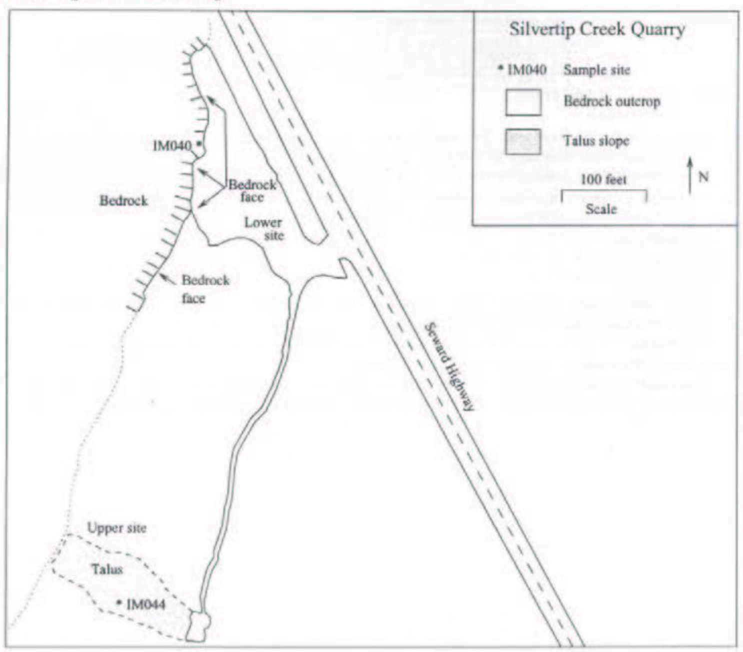
North Granite Creek Timber Road Potential Rock Source Site Map

Attachment 4. Mineral Materials site maps, Sixmile/Canyon Landscape Assessment Area

From Sherman and others, 1997



Silvertip Pit Site Map



Silvertip Creek Quarry Site Map

b. Rock

1. Hope Highway, Mile 2 Slate

This rock source is adjacent to and parallels the Hope Highway near mile 2. It consists of an 800-foot-long cliff approximately 30 feet high and the talus derived from it. The thickness of the deposit is unknown. The rock is a primarily a dark-gray slate with nearly vertical cleavage. Most of the slate is generally of fair quality for use as decorative stone, fireplace facing, pathways and the like. Most of the material is too soft and the cleavage is not perfect enough for it to be used as shingles for roofing, flooring, or for blackboards.

The outcrop is nearly vertical with an apron of talus. The talus angle of repose is about 30 degrees. The flat, thin nature of the material tends to allow it to slide/move easily, thereby not retaining a steep slope. “New” rock comes down mostly in the spring, in response to freeze/thaw forces. Heavy rains may cause some loose rock to migrate downward.

Figure 8. Slate rock source at mile 2 of the Hope Highway. Photo taken by Carol S. Huber, looking west toward Hope.

BLM visited this source in 1996 but did not include it in their Mineral Materials Survey report (Sherman and others, 1997).

2. Hope Highway, Mile 4 Slate

This undeveloped rock source is exposed along the Hope Road near mile 4. The rock exposed in the road cut consists of massive greywacke on the south end, brown slate in the middle, and gray slate on the north end. The gray slate exhibits a parallel cleavage. The material has potential for decorative stone, although the resource is limited to an area of 15 feet high by 25 feet long by 10 feet wide. There may be as much as 100 feet of additional material along strike. The slate appears similar in quality to the slate at Mile 2.

3. North Granite Creek Timber Road

This undeveloped rock source is on the north side of the Seward highway near the Granite Creek campground entrance (Attachment 3). The site had an active salvage logging in 1996 when the BLM conducted their mineral material survey (Sherman and others, 1997). The road construction and logging operation exposed several outcrops of greywacke (Attachment 4). There has been no excavation of rock from this site other than that needed for the logging road construction.

The rock exposure at the end of the road consists of slate that breaks into sharp flat pieces. The slate is too soft for riprap or crushed aggregate and the BLM took no samples. The rock exposure near the logging camp consists of a hard, dark gray greywacke with interbedded phyllite units. The exposure parallels the road for approximately 250 feet. The bedrock knob is approximately 40 feet high. Additional bedrock is exposed near the camp. The quality test results (Figure 7) indicate this site has potential as a source for riprap and crushed aggregate for pavement. The test results further indicate that the rock is unsuitable for use as aggregate for base.

Assuming a quarry size of approximately 250 by 250 feet, 40 feet high, there is a potential for a minimum of 200,000 tons of rock (Sherman and others, 1997). This estimate only includes the area where trees have been logged off. Greater resources are present since the bedrock continues up the slope and is also exposed in other logged off areas.

4. Silvertip Creek Quarry

This quarry is on the south side of the Seward Highway, just west of Silvertip Creek. The rock has been used as a source of riprap and shot rock. There are two distinct areas at this rock source (Appendix 5). This is not the same site as the Silvertip quarry, which is on state land.

Rock at the lower site is a dark gray greywacke with crosscutting quartz, calcite, and tremolite veins. There are some phyllite/schist inclusions in the western face. The material breaks into a variety of sizes when blasted and the maximum size is 4- to 6-foot pieces. The resource appears to be limited to approximately 100 feet from the face by a fault trace. The BLM did not estimate a resource for this site because they believed that is had limited development potential due to its proximity to the highway (Sherman and others, 1997).

Rock at the upper site consists of blocky greywacke boulders varying in size up to approximately 10 feet. The material is dark gray with quartz veins. This site is a talus slope that is approximately 250 feet long and 30 to 50 feet wide; it has an estimated average depth of 6 feet. The estimated rock resource is 8,250 tons (Sherman and others, 1997).

c. State Owned Mineral Materials

There are additional potential resources on State land within the assessment area; they are situated within 3 blocks of lands that are (1) near the mouth of Sixmile Creek, (2) the "forks", and (3) along Canyon Creek north of Summit Lake (Attachment 6). Block 1 does not contain any known materials pits, but does have potential for sand and gravel. Block 2 contains 2 known materials pits and 1 quarry. Pit 1 is at the Alaska Department of Transportation (ADOT), Silvertip Station, and has been used extensively. Pit 2 has had minor usage in highway construction and reconstruction. Quarry 1, the Silvertip Quarry, has had extensive use in Highway construction and reconstruction. Block #4 contains gravel pits 3 and 4. Gravel pit 3 is located at mile 48.6 on the east side of the highway. It has been used extensively for the highway. ADOT has designated this pit as MS #31-1-025-1. Gravel pit 4 is located on the west side of the highway north of Colorado Creek at mile 46.5. ADOT has designated this pit as MS #31-1-014-1. Some 300,000 cubic yards was extracted from Gravel pit 3 in 1994 through 1998 for highway reconstruction. Gravel pit 4 was used for disposal of unusable material. Both pits belonged to the Forest Service at in 1994 and were transferred to State ownership in 1996.

1. Silvertip Quarry

The rock is a fractured greywacke belonging to the Valdez Group. The quarry is located on the west side of the Seward Highway, 2.5 miles southeast of the Hope "Y", in the NW¼ Section 26, T. 8 N., R. 1 W., Seward Meridian. (The Silvertip Creek Quarry is in section 36.) Prior to 1977, this quarry has been used as a source of riprap for highway construction. From 1977 to 1981 it was used as a source of rock for fireplace construction (Hoekzema and Sherman, 1983).

2. Mining effects on watershed

D. Current Mining

Mineral materials have been mined historically in the assessment area and are being mined currently. The East Fork pit is the only active Forest Service materials pit in the assessment area, although there several old pits that could be used, if needed. East Fork pit is managed out of the Glacier Ranger District as a community pit. They issue several permits annually from this pit. Most of the material is sold for highway reconstruction or maintenance projects.

Mining Claims and Operations

A. Mining Claims

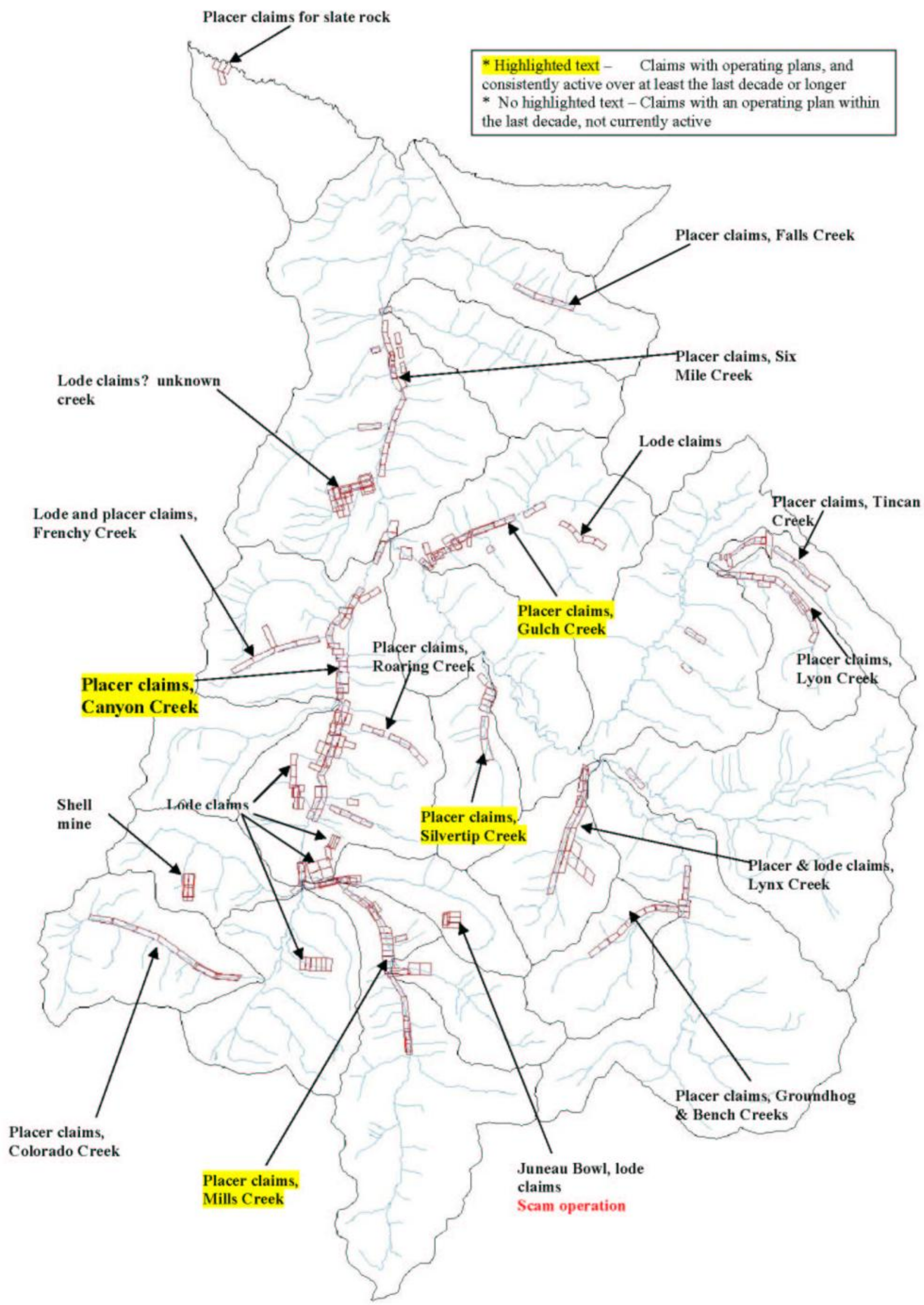
The major Federal law governing locatable minerals is the Mining Law of 1872 (May 10, 1872), as amended (30 U.S.C. 22-54). This law provides citizens of the United States the opportunity to explore for, discover, and purchase certain valuable mineral deposits on those Federal lands that remain open for that purpose. These minerals include metallic minerals and certain nonmetallic minerals. The Chugach National Forest is mostly open to mineral entry, and lands in the assessment area are generally open to mineral entry. Withdrawn areas include the (1) highway corridor that includes a strip of land along both sides of the highway, (2) campgrounds and other developed areas, (3) State land selections. State mining claims may be located on lands that have been conveyed to the state. In some cases, federal mining claims preexist a state land selection; in that instance these claims remain federal mining claims (federal land) when the selection in conveyed. If the claims are later abandoned, then that piece of land occupied by the former claim may be conveyed to the state.

A mining claim is a property right but it is not property ownership. Instead, mining claim ownership carries the right to use a parcel of land (mining claim) but that use is restricted to prospecting, mining or processing the mineral resource and uses reasonably incident thereto. A mining claim on national forest land is still public land, and ownership of a mining claim does not carry exclusive possession of that land. The ownership of a mining claim carries both rights and obligations; these are discussed in the Forest Service Manuel (FSM) 2813. Section 2814 of the FSM discusses the rights and obligations of the United States with regards to mining claimants.

Forest wide, there are generally about 500-600 mining claims, nearly all on the Kenai Peninsula. There are a number of mining claims in the assessment area; they are located mostly along known placer streams or over known lode prospects. They also tend to be staked more readily in easily accessible areas. The majority of them are placer claims rather than lode. Attachment 5 shows mining claims in the assessment area that were current in 1998. The number of mining claims at any particular time is subject to change as new claims are filed and existing claims are abandoned. Maintaining a mining claim requires an annual fee payment or filing of annual assessment work. If neither is done, claims are deemed abandoned and void.

The presence of mining claims may indicate an interest in developing the mineral resource. Not always however, sometimes mining claims are staked on speculation. Sometimes claimants locate mining claims in order to possess and use Federal lands for nonmining purposes. This is an illegal practice but is actually fairly common. Mining claims may only be used to develop and mine the mineral resource. When activities on a mining claim entail disturbance of surface resources, a notice of intent or plan of operations must be submitted for Forest Service approval. Even though the mining law allows such activities, the Forest Service must still approve activities that would take place on national forest land.

Attachment 4. Mining claims/operations in the Canyon Creek/Sixmile Creek Landscape Assessment Area



B. Locatable Mining Operations

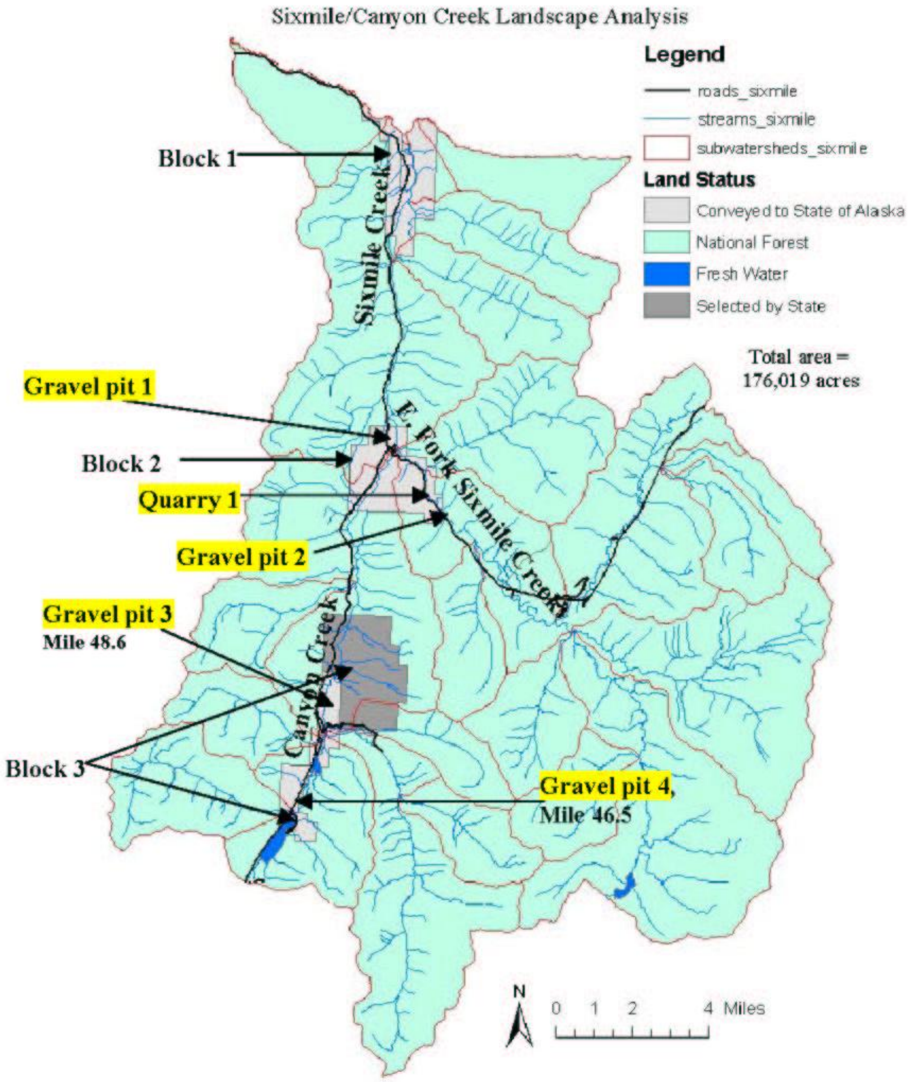
The United States has the right to regulate prospecting and mining activities; this right is contained in 16 USC 551, and exercised in among other regulations, 36 CFR 228 Subpart A. These Forest Service regulations set the rules through which the mining claimant may use the surface of National Forest System lands in connection with operations authorized by the United States mining laws. The regulations seek to manage public lands so as to minimize adverse environmental impacts of surface resources.

Currently, there are approved suction dredging plans of operations on several streams in the assessment area. Attachment 5 shows the mining claims that either currently have or recently (within the last 5-10 years) had approved plans. The current and most consistently active claims with operations are highlighted in yellow. These are situated on Canyon, Mills, Silvertip, and Gulch Creeks; all of these streams are historic producers. The largest producer by far is Canyon/lower Mills Creek. This area it has experienced the most intense activity in recent years. The Gold Prospectors Association of America (GPAA) the world's largest prospecting organization, owns several claims on Mills Creek. On GPAA claims, there has been considerable suction dredging and hand-mining activity for the past 8-10 years and currently. These claims cover historically mined areas.

No heavy equipment mining is currently occurring. The most recent (early 1990s) heavy equipment placer mining on the "Goodrock D" mining claim occurred on the east side of the Seward Highway, in the bench gravels along Canyon Creek near its confluence with Mills Creek. Mining occurred for several consecutive years during that period. The land has since been conveyed to the state. No federal mining claims exist within the conveyed parcel.

No lode mining is occurring, either copper or gold. Prospecting continues to occur intermittently in the assessment area. In general, this prospecting has not required a plan of operations.

Attachment 6. Mineral Material Sources on State and State Select Lands in the Sixmile/Canyon Creek Landscape Assessment Area



E. Land Status

Introduction

Easements and Permits within the 6 Mile/Canyon Creeks Watershed

F. Cultural Resources

Humans have used the Sixmile/Canyon Creek Watershed spanning a period of about 10,000 years. The cultural resources of the watershed include prehistoric and historic remains. Some of these properties are either on or are eligible for the National Register of Historic Places. The historic mining resources constitute the greater part of the known cultural resources in the watershed, although large portions of the project area have not yet been inventoried. The National Historic Preservation Act (Section 106) and Executive Order 11593 require archaeological inventory to be completed prior to implementation of any undertaking. Prior to the late 1990s, however, funding for completing heritage reports was often not provided. Therefore some information gathered from surveys completed in the past 20 years has not been reported. The majority of the cultural resources currently identified within the watershed remain formally unevaluated for the National Register of Historic Places (NRHP). Only Sunrise City (SEW-00820) has been evaluated and placed on the NRHP.

Through research of previously written books and reports completed in ecologically similar areas, it is possible to infer the early cultural use of the sixmile watershed. Artifacts from every period of human occupation have been discovered in the region. The earliest known site in the Cook Inlet area is located at Beluga Point on the north side of Turnagain Arm. This site contained Paleo-Arctic core and blade technology. Use of the area was probably due to the abundance of sheep, caribou and fish. Artifacts from the Middle Holocene have been found along the Kenai River in the interior of the Kenai Peninsula (McMahan 1985: 197-198). In addition, a large number of sites from the late prehistoric period (after about 1,000 years ago) have been located throughout the region. Prehistoric period sites are characterized by rectangular house depressions, other pit features, and a preponderance of cobble spall scrapers, but few other preserved artifacts. Archaeological evidence suggests that Athapaskans occupied the region around Cook Inlet beginning about 700 years ago, and thus, sites dating from the late prehistoric period are presumed to relate to Tanaina Athapaskan occupation (McMahan et al. 1991; McMahan 1995).

Earliest known Euro-Americans to visit the Cook Inlet region were English explorers. Captain James Cook sailed into the inlet in 1778. In the 1790's Russian fur traders began setting up posts on Cook Inlet to develop the fur trade. While the primary focus of Russian activity was the fur trade, the Russians prospected the surrounding area for gold (c.f. Korman 1989:164). Euro-American influence had little impact on the Turnagain Arm area until the first gold discovery there in 1890. In 1893 prospectors staked the first mining claims in the area and established mining camps at the mouths of the Resurrection and Sixmile creeks in 1895. During 1895, prospectors fanned out through the Turnagain Arm area looking for additional sources of gold. Sam Mills and J.T. Ballam filed the first claims on Canyon Creek, a tributary of Sixmile Creek, the next major drainage east of Resurrection Creek. Other prospectors filed claims on Sixmile, Canyon, East Fork, Mills, and Lynx creeks. Gold discoveries on Canyon and Mills creeks produced the richest returns, setting off a stampede of outside prospectors to Turnagain Arm the following year. In 1896 about 1,500 men and women worked the Sixmile drainage, establishing the Sunrise Mining District (Moffit 1906:9; Barry 1973:61). As pressure on the resources grew, people began settling wherever suitable land for dwellings could be located.

The northern part of the Kenai Peninsula contains commodities of gold, silver, copper, lead, zinc and molybdenum. Mining has included significant placer gold production, over 100,000 ounces from 1895 to present. Lode production includes a small amount of gold, about 13,500 ounces prior to World War II (Selkregg 1974:I-71). Mining came to a halt in the early 1940s with the Preference Rating Order of 1941, and the Limitation Order L-208 of 1942 (Berry 1997:210). Although L-208 was revoked July 1, 1945, mining never recovered its pre-war economic importance. The early twentieth century is considered a key period of historic significance for the Sixmile/Canyon Creek Watershed, to which the majority of the historic mining remains are linked.

Cultural Resources current condition

Forest Service management of cultural resources is legislated by Acts of Congress and Executive Orders. They mandate inventories of cultural resources, and preservation and interpretation of all types of cultural resources for the benefit of the public. The requirements of three of these, plus a Programmatic Agreement between Region 10 of the Forest Service, the State Historic Preservation Officer and the Advisory Council on Historic Preservation, are summarized in Appendix A.

Of the 181,170 acres that comprise the total area of the Sixmile/Canyon Creek Watershed, about 1,208 acres, or about .6% of the total area has been surveyed for cultural features (CNF Heritage Program files). These surveys have been project related and so are discontinuous in nature with a rather checkerboard appearance when plotted on a map. Maps of archaeological surveys completed after 1992 are not provided due to the lack of funding allocated to update the GIS layers. The GIS map completed to date would show less than half of the areas actually surveyed.

Four Alaskan Native related sites are known to be located within the watershed boundaries. These resources consist of flaked stone tools, cache pits and house depressions. The four sites known are:

SEW-00106 Hope Cutoff Site
SEW-00608
SEW-00609
SEW-00696 Log Cache

Sixty-five mining and Euro-American historic properties are currently documented within the watershed. The features at these sites include: cabins, ditches, bridges, cemeteries, and mining related artifacts and features. The 65 known historic sites are:

SEW-00022 Dahl ("Quartz Creek")
SEW-00035 Michaelson Family Cemetery
SEW-00036 Canyon Creek Wing Dam
SEW-00094 Tunnel, Railroad Station
SEW-00100 Portage Roadhouse
SEW-00104 Griset's Roadhouse
SEW-00105 White's Roadhouse
SEW-00112 Tunnel 7
SEW-00113 Falls Creek Cabin
SEW-00114 Woodrow ("Bear Creek Station")
SEW-00115 Tunnel 0
SEW-00118 Johnson ("Sunrise R.R. Station")
SEW-00149 Saxton Camp ("Wilson's Camp")
SEW-00152 Lauritsen Cabin

SEW-00194 Sunrise
SEW-00195 Sunrise Cemetery
SEW-00256 Canyon Creek Trail
SEW-00365 Saxton Ditch
SEW-00366 Johnson Pass Military Road
SEW-00367 Lower Fuller Creek Ditch
SEW-00368 Upper Fuller Creek Ditch
SEW-00369 Ditch Features
SEW-00370 Ditch Features
SEW-00371 Gaede Cabin
SEW-00372 Pass Creek Ditch
SEW-00373 Wible Ditch
SEW-00374 Wible Mining Camp
SEW-00375 Donaldson Creek Ditch
SEW-00376 Lower Donaldson Creek Ditch
SEW-00377 Ditch Features
SEW-00378 Ditch Features
SEW-00379 Ditch Features
SEW-00380 Lower Canyon Creek Ditch
SEW-00381 East Fork Ditch
SEW-00382 Mining Shaft
SEW-00383 Granite Creek/Ingram Creek Trail Co.
SEW-00384 Frenchy Creek Ditch
SEW-00603 Walker Cabin
SEW-00604 Cascade Cabin
SEW-00605 Mills Creek Cabin Site
SEW-00655 Canyon Creek Bridge
SEW-00683 Falls Creek Camp Site
SEW-00684 Falls Creek Mining Ditch
SEW-00685 Ruins of 8-sided Cabin
SEW-00686 Falls Creek Log Cabin
SEW-00687 Log Cabin
SEW-00688 Part from Sixmile Dredge
SEW-00689 Cabin Foundation and Domestic Artifacts
SEW-00690 Partially Buried Wash Tub
SEW-00691 Root Cellar and Artifacts
SEW-00692 Three Depressions and Artifacts
SEW-00693 Cabin Foundation and Artifacts
SEW-00694 Cabin Foundation and Three Depressions

SEW-00695 Cabin Foundation and Artifacts
SEW-00697 Ruins of Two Log Cabins
SEW-00777 Unit 22A Mining Ditch
SEW-00778 Unit 18E Mining Ditch
SEW-00779 Unit 18F Road and Associated Ditch
SEW-00789 Root Cellar and Three Depressions
SEW-00820 Sunrise City National Register Historic District
SEW-00833 Cabin Site on the Island
SEW-00949 East Fork Concrete Truck
SEW-00964 Granite Creek Guard Station
SEW-00965 East Fork Cabin
SEW-00968 Boston Bar

A number of these and other historic properties are undoubtedly eligible for the National Register of Historic Places, but they have yet to be properly documented or evaluated.

Another type of heritage site that needs to be addressed here are cultural landscapes. Cultural Landscapes are a type of historic property addressed in the Secretary of the Interior's Standards and Guidelines, as revised in 1992. A cultural landscape is defined as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values: (Birnhaum 1994:1). Cultural landscapes generally fall into one of four categories: historic designed landscapes, historic vernacular landscapes, historic site landscapes, or ethnographic landscapes. The size of cultural landscapes can vary from as little as half an acre to hundreds of acres.

Although "Most historic properties have a cultural landscape component that is integral to the significance of the resource" (Birnhaum 1994:2), the cultural landscape elements have not been fully inventoried or evaluated for any of the historic properties in the Sixmile/Canyon Creek watershed. Mining landscapes fall under the category of historic vernacular landscape, "a landscape that evolved through use by the people whose activities or occupancy shaped the landscape" (Birnhaum 1994:2). In this case the Sixmile/Canyon Creek Watershed can be expected to include a vernacular landscape. The historic period with which most of the cultural landscapes in the watershed are associated is the early 20th century. The features that contribute to the historic character of the cultural landscape include the physical environment and ecological systems of the region, views and vistas, mining areas, living areas, patterns of land division, vegetation and associated changes, tailing piles, ponds and ditches, the historic cabins and outbuildings, trails and roads, and indigenous and introduced vegetation.

Cultural Resources Reference Conditions

Three reference condition periods exist for the Sixmile/Canyon Creek Watershed: the pre-European fur trade period (prehistoric); the Euro-American fur trade period, which directly impacted the wildlife of the Kenai Peninsula, and indirectly affected its vegetation; and the American mining period/early Chugach Forest period (1888-1942), during which human use changed some drainage patterns, and resulted in changes to botanical and biological resources.

During the pre-contact period (pre-A.D. 1778) Alaskan Natives used biological and botanical resources for food, clothing, shelter and transportation. Although the biological and botanical populations and their distribution as recorded at the time of European contact are often viewed as representative of a "pristine" state, these populations are simply indicative of their state given the technology of the human groups that harvested them, and the population size of those human groups at that time. In fact these populations were effected greatly by early human populations through the use of fire, and by hunting and gathering.

During the "Fur trade period" of A.D. 1778 to 1888 there was increased harvesting by Alaska Natives and non-Natives of land mammals, such as beaver, land otter, marmot, fox, lynx, caribou, sheep, wolf, bear and wolverine. A decrease in numbers of beavers would have had an impact on the vegetation and the hydrology of the Sixmile Creek watershed. There is documentation from other parts of the Kenai Peninsula of people catching Anadromous fish to sell to Euro-American settlers. If this was an economic strategy of the Native Alaskans of the Sixmile/Canyon Creek watershed, such activities may have had a detrimental effect on Sixmile Creek fish populations. Decreases in populations of fur bearers and related changes in human socialization patterns may have caused changes in human settlement patterns in the Sixmile Valley, as is apparent in other parts of the Kenai Peninsula. These would be evident in the locations and types of sites from particular time periods.

The American mining period/early Chugach Forest period (1888-1942) is one of the best-documented historic eras. Mining camps were established in proximity to streams, whose water was used for placer and hydraulic mining. Water was not as much of a concern as the location of mineral veins for some later hard-rock mines, which were established away from major streams. Mining related machinery was brought in, and buildings, ditches, and roads were constructed. Early 20th century photos of the areas adjacent to Sixmile Creek show widespread clear-cut areas throughout the valley, especially near the town of Sunrise, as late as the 1930s. Populations of fish and land mammals likely continued to decrease as a result of human subsistence use and changes to the Sixmile Creek stream bed.

1. Physical Setting

A. Climate

Various weather stations are located in and around the Sixmile/Canyon Creek analysis area. The weather station in Hope, AK, at 150 feet elevation, is approximately 7 miles west of the mouth of Sixmile Creek and represents the rain shadow influence on this north-central portion of the Kenai Peninsula. The weather station at Moose Pass 3 NW, AK, at 480 feet elevation, is approximately 9 miles south of Summit Lake and represents the influence of a transition maritime and mountainous interior climate (**table 2.II.A-1**, **figure 2.II.A-1**). Both of these weather stations are low in elevation and may not be representative of higher elevation areas within the Sixmile/Canyon Creek watershed.

Climate varies dramatically throughout the Kenai Peninsula and the Sixmile/Canyon Creek analysis area. In general, precipitation increases with increasing elevation in the watershed. Also, precipitation is considerably greater in the eastern portion of the watershed, as it is more subjected to the maritime influence of Prince William Sound east of the Kenai Peninsula (**figure 2.II.A-2**). A result of this weather phenomenon is the abundance of glaciers on the eastern portion of the Sixmile Creek watershed, as well as on the eastern portion of the Kenai Peninsula. The climate is uniquely different in Portage Valley, just 5 to 10 miles northwest of the Sixmile Creek watershed, where winds and moisture cross the low Portage Pass and create extreme climatic conditions.

Table 2.II.A-1: Weather station metadata for the Sixmile Creek watershed. Climate data from WRCC (2002), snow data from NRCS (2002).

Climate data (WRCC)								
Number	**Station Name**	**Lat**	**Long**	**Elev**	**Start**	**ObsTyp**		**End**
(Coop)	(From NCDC listing)	ddmm	dddmm	ft	yy mm	t	p	yy mm
505894-2	MOOSE PASS	6028	14923	480	52 03	U	U	67 09
505894-2	MOOSE PASS	6028	14923	490	67 09	U	U	78 09

505894-2	MOOSE PASS 3 NW	6030	14926	490	83 01	1	2	88 07
505894-2	MOOSE PASS 3 NW	6030	14926	480	88 07	1	2	99 99
503720-2	HOPE	6055	14938	150	79 02	U	U	99 99

From NCDC Station Historical Listing for NWS Cooperative Network
ObsTyp: t-Temperature-1, p-Daily precip-2, w-(blank), s-(blank), e-Evap-5
h-Hourly precip - 6 0.01" Universal, or - 7 0.10" Fisher-Porter
U - Observed, but beginning date is uncertain

Snow data (NRCS)						
Number	**Station Name**	**Lat**	**Long**	**Elev**	**Start**	**End**
		ddmm	dddmm	ft	yy mm	yy mm
49L19S	Summit Creek (SNOTEL)	6037	14932	1400	61 10	90 09
49L13S	Turnagain Pass (SNOTEL)	6047	14911	1880	61 10	90 09
49L02	Bertha Creek (Snow Course)	6045	14915	950	61 10	90 09
49L03	Kenai Summit (Snow Course)	6040	14929	1390	61 10	90 09

Figure 2.II.A-1: Weather stations, stream gauge sites, and water quality measurement sites in the Sixmile/Canyon Creek analysis area. Locations of USFS water quality sites are approximate.

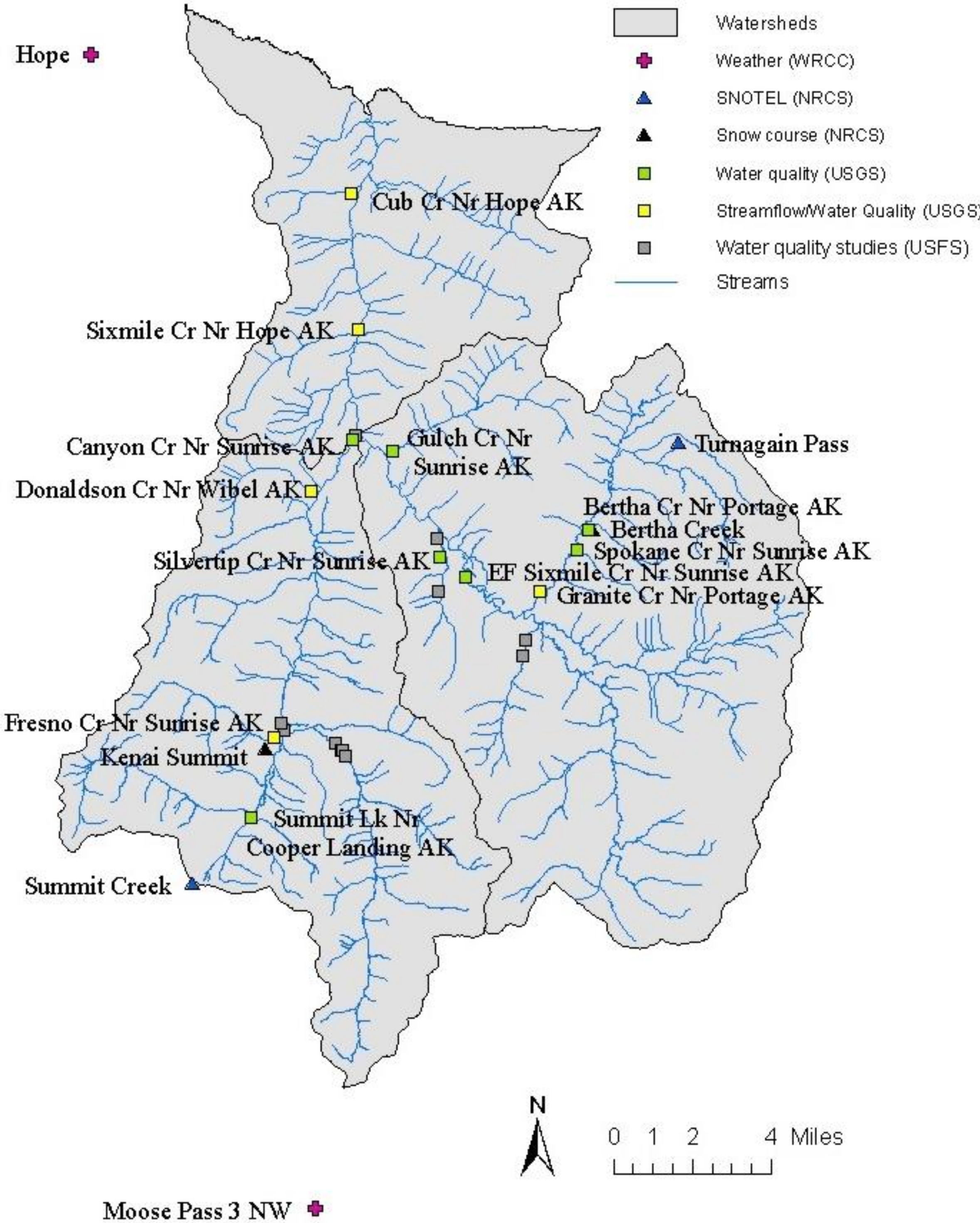
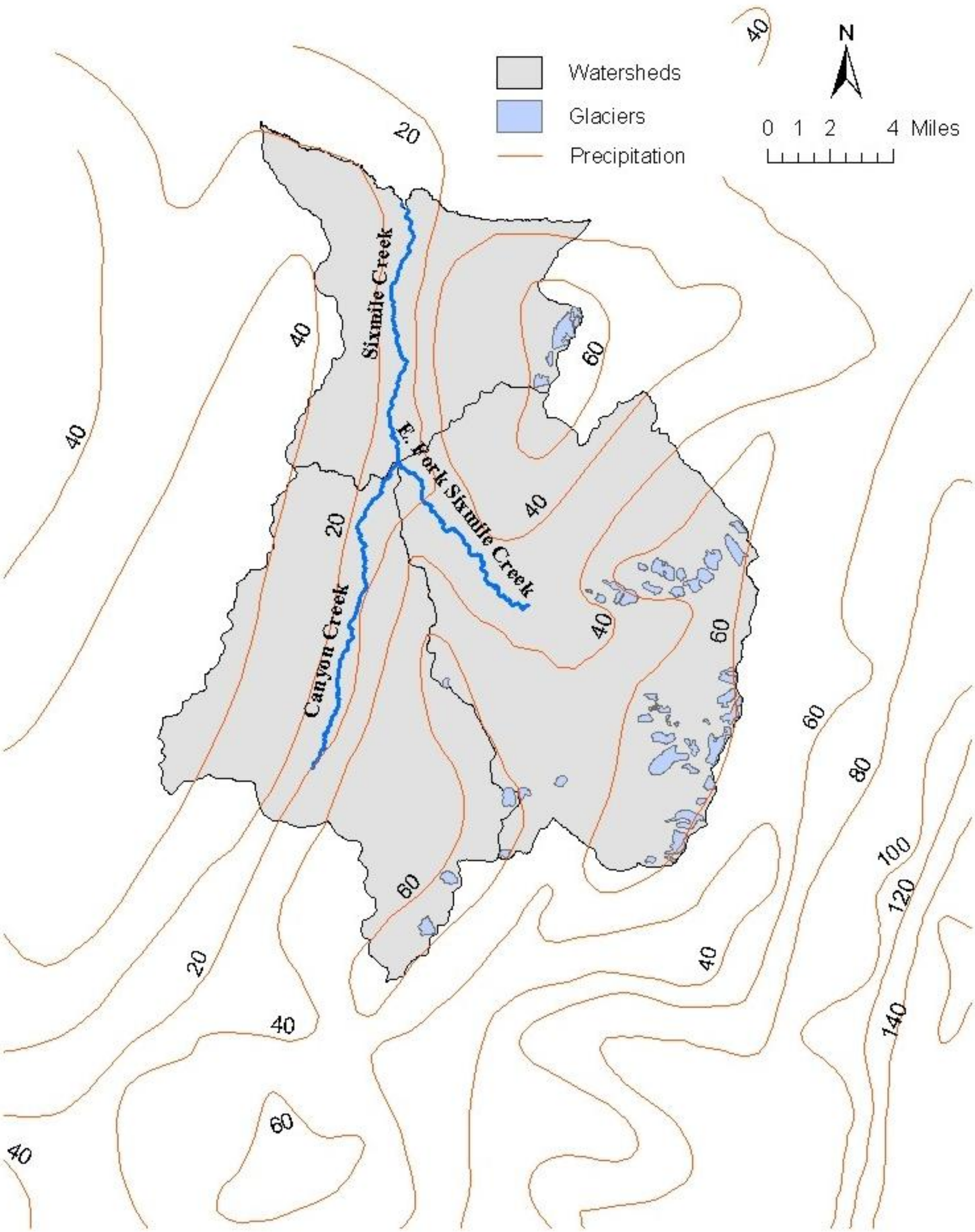

Watersheds
Weather (WRCC)
SNOTEL (NRCS)
Snow course (NRCS)
Water quality (USGS)
Streamflow/Water Quality (USGS)
Water quality studies (USFS)
Streams
Hope
Cub Cr Nr Hope AK
Sixmile Cr Nr Hope AK
Canyon Cr Nr Sunrise AK
Gulch Cr Nr Sunrise AK
Turnagain Pass
Donaldson Cr Nr Wibel AK
Bertha Cr Nr Portage AK
Bertha Creek
Spokane Cr Nr Sunrise AK
Silvertip Cr Nr Sunrise AK
EF Sixmile Cr Nr Sunrise AK
Granite Cr Nr Portage AK
Fresno Cr Nr Sunrise AK
Kenai Summit
Summit Lk Nr Cooper Landing AK
Summit Creek
N
0 1 2 4 Miles
Moose Pass 3 NW

Figure 2.II.A-2: Mean annual precipitation (in inches) in the Sixmile/Canyon Creek watershed. Glaciers are present in the alpine areas of the watershed that receive more precipitation.



1. Air Temperature

At Moose Pass, the mean annual temperature is 35.3 degrees F, the mean minimum January temperature is 4.6 degrees F, and the mean maximum July temperature is 66.5 degrees F. At Hope, the mean annual temperature is 36.7 degrees F, the mean minimum January temperature is 12.8 degrees F, and the mean maximum July temperature is 66.5 degrees F (WRCC, 2002) (**table 2.II.A-2, figure 2.II.A-3**). Although average temperatures are relatively similar at these two weather stations, temperatures at Moose Pass fluctuate more widely than those at Hope, leading to greater maximum temperatures and smaller minimum temperatures. Because the town of Moose Pass lies in a somewhat enclosed basin, temperature inversions and cold winter temperatures are common (Blanchet, 1986). The smaller temperature fluctuations in Hope are the result of the maritime influence of Turnagain Arm and Cook Inlet, and the lower frequency of winter temperature inversions.

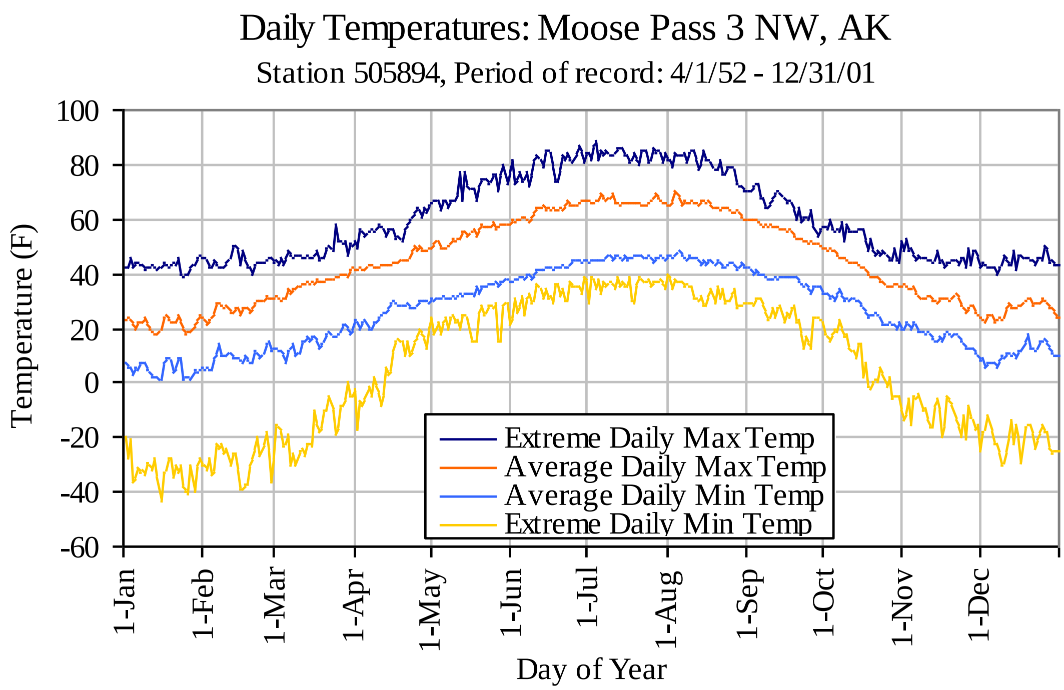
Table 2.II.A-2: Monthly climate summary for Moose Pass 3NW, AK, Hope, AK, Summit Creek, AK, and Turnagain Pass, AK. Data from WRCC (2002) and NRCS (2002).

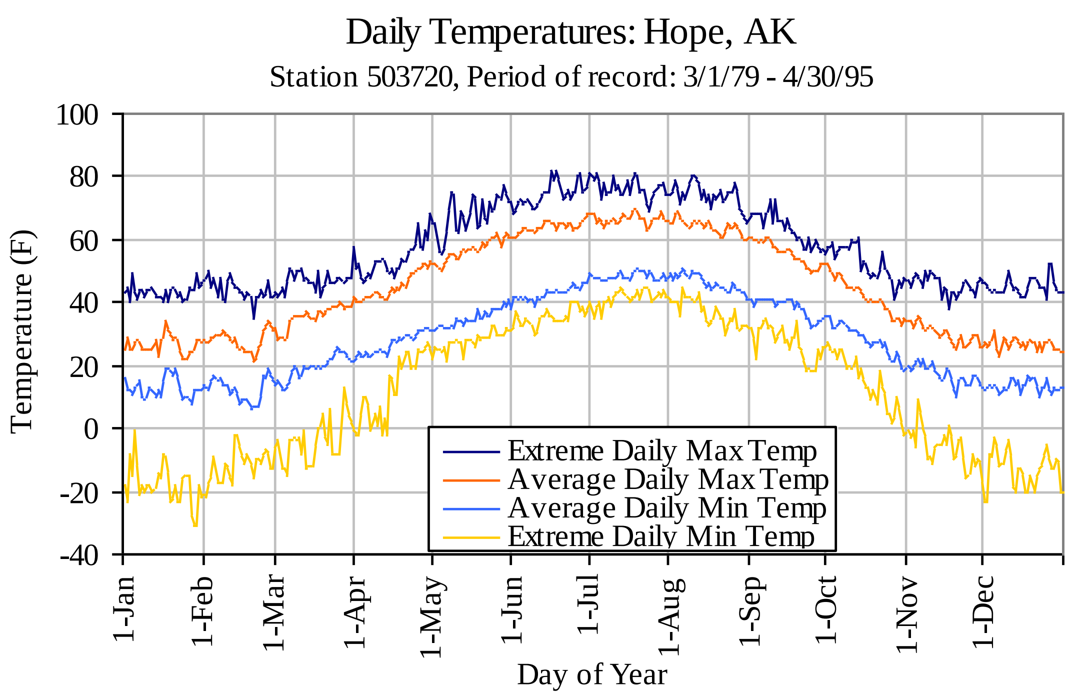
Moose Pass 3 NW, AK (505894)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	21.5	27.2	36.2	44.4	54.4	63.2	66.5	64.7	55.2	41.9	31.2	27	44.5
Average Min. Temperature (F)	4.6	9.9	15	25.8	33.5	41.3	45.8	44.6	37.9	27.4	17	11.3	26.2
Average Mean Temperature (F)	12.9	18.7	25.6	35.1	44	52.2	56.2	54.6	46.5	34.7	24.4	19.1	35.3
Average Total Precipitation (in.)	1.89	2.46	1.24	1.05	1.4	0.83	1.45	2.76	4.92	4.31	3.07	3.11	28.48
Average Total SnowFall (in.)	14.3	16	11.4	4.3	0.1	0	0	0	0.1	4.4	11.8	20.2	82.6
Average Snow Depth (in.)	12	16	15	7	0	0	0	0	0	0	3	11	5
Data from WRCC (2002). Period of Record : 4/ 1/1952 to 12/31/2001. Percent of possible observations for period of record: Max. Temp.: 60.5% Min. Temp.: 60.3% Precipitation: 60.4% Snowfall: 58.1% Snow Depth: 57.1%													

Hope, AK (503720)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	26.6	28	36	45.2	56.7	64.2	66.5	64.2	55.6	41.9	30.1	26	45.1
Average Min. Temperature (F)	12.8	12.6	19.4	27	35.2	42.9	48.3	46.1	38.6	28.1	17	12.7	28.4
Average Mean Temperature (F)	19.7	20.3	27.7	36.1	46	53.5	57.4	55.1	47.1	35	23.6	19.4	36.7
Average Total Precipitation (in.)	1.98	1.43	1.2	0.74	0.62	1.09	1.95	2.53	3.28	2.68	2.1	2.57	22.15
Average Total SnowFall (in.)	13.6	15.1	11.3	3.3	0.1	0	0	0	0.1	5.7	17.8	22.7	89.5
Average Snow Depth (in.)	11	12	11	3	0	0	0	0	0	1	4	10	4
Data from WRCC (2002). Period of Record : 3/ 1/1979 to 4/30/1995. Percent of possible observations for period of record: Max. Temp.: 98.7% Min. Temp.: 98.8% Precipitation: 97.7% Snowfall: 98.5% Snow Depth: 97.9%													

Average Total Precipitation (in)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Summit Cr. (SNOTEL 49L19S)	2.7	2.4	1.9	1.9	1.7	1.9	2	3	4	4.1	2.9	3	31.5
Turnagain Pass (SNOTEL 49L13S)	6.5	5.4	5	4.4	2.5	2.4	2.3	4.3	7.2	7.4	6	6.7	60.1
Data from NRCS (2002). Period of record: 1961 - 1990													

Figure 2.II.A-3: Daily temperatures for Moose Pass 3NW, AK (Station 505894) and Hope, AK (Station 503720). Data from WRCC (2002).





2. Precipitation

Moose Pass receives an average of 28.5 inches of precipitation per year, and Hope receives an average of 22.2 inches per year (WRCC, 2002) (**table 2.II.A-2, figure 2.II.A-4**). Precipitation in the watershed increases with elevation, as well as in an eastward direction. Precipitation data from SNOTEL sites in the watershed show an average annual total precipitation of 31.5 inches per year at Summit Creek, located at 1400 feet in the headwaters of the Canyon Creek watershed. However, the average annual total precipitation at Tincan Mountain on Turnagain Pass, located at 1880 feet in the eastern portion of the watershed, is 60.1 inches per year, almost twice that at Summit Creek. Although this is partially an effect of the greater elevation at the Turnagain Pass site, it also reflects the direction that storms circulate through Prince William Sound. In this case, the Kenai Mountains act as a barrier to create a rain shadow effect west of the mountains. This rain shadow effect causes the East Fork Sixmile Creek watershed to receive considerably more precipitation and create more runoff than the Canyon Creek watershed.

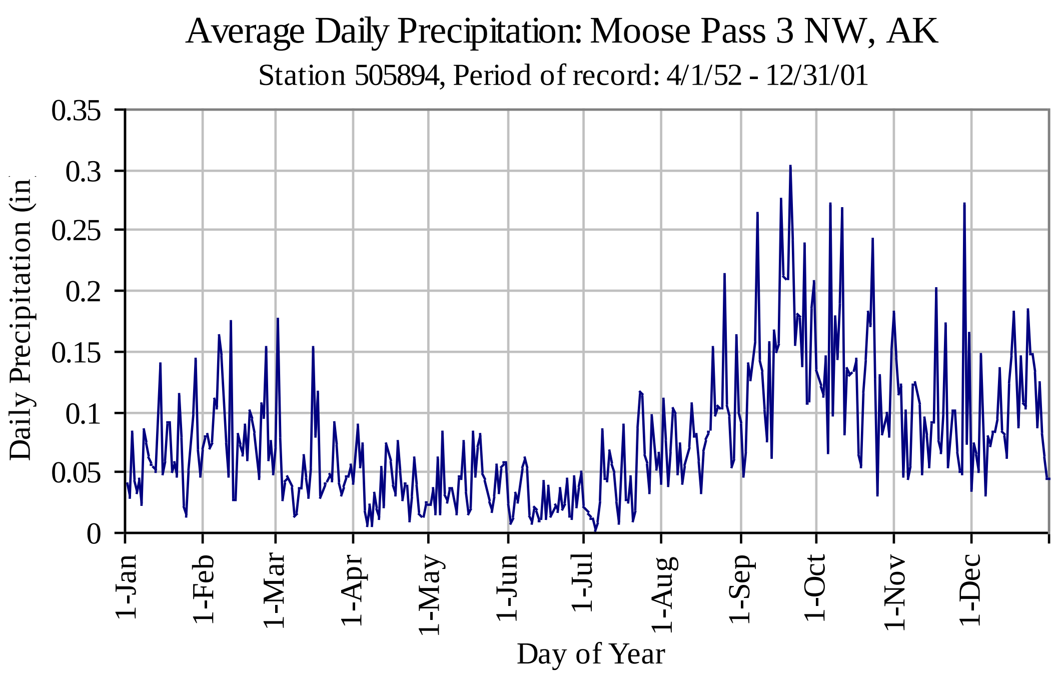
Both snow and rain occur in the Sixmile Creek watershed. Snow falls at all elevations of the watershed between the months of October and April, although winter warm spells can bring rain to the lower elevations. These winter rains often occur earlier in the season below about 800 feet in elevation (Blanchet, 1986). In general, about 50% of the annual precipitation in the lowest elevations comes as snow, and this increases to about 75% in the highest elevations in the watershed. September and October are the wettest months of the year at all measured locations, and winter months receive more precipitation than summer months. May is generally the driest month of the year (**table 2.II.A-2, figure 2.II.A-4**). Storms in the Turnagain Pass area generally last an average of 1.5 days (Blanchet, 1986).

3. Snowpack

Two SNOTEL sites and two snow courses, all monitored by the Natural Resources Conservation Service (NRCS), are located within the Sixmile/Canyon Creek analysis area (**table 2.II.A-3, figure 2.II.A-5**). Snowfall measurements are also recorded at Moose Pass and Hope by the Western Regional Climate Center (WRCC) (**table 2.II.A-2, figure 2.II.A-6**). These data show a wide variability in snow depths throughout the watershed.

Tincan Mountain at Turnagain Pass and the upper elevations of the eastern portion of the watershed receive the most snow. This site has an average of 38.6 inches of snow water equivalent persisting into May, and on average has snow remaining on the ground through June. Bertha Creek, about 5 miles southwest of Turnagain Pass and at 950 feet elevation, receives considerably less snow, with only 18.9 inches of snow water equivalent at the beginning of May. Summit Creek and Kenai Summit, both located in the headwaters of Canyon Creek, represent the drier western portion of the watershed, with average snowpacks of about 13 inches of snow water equivalent occurring in April, and snow remaining on the ground only until late May.

Figure 2.II.A-4: Average daily precipitation for Moose Pass 3 NW, AK (Station 505894) and Hope, AK (Station 503720). Data from WRCC (2002).



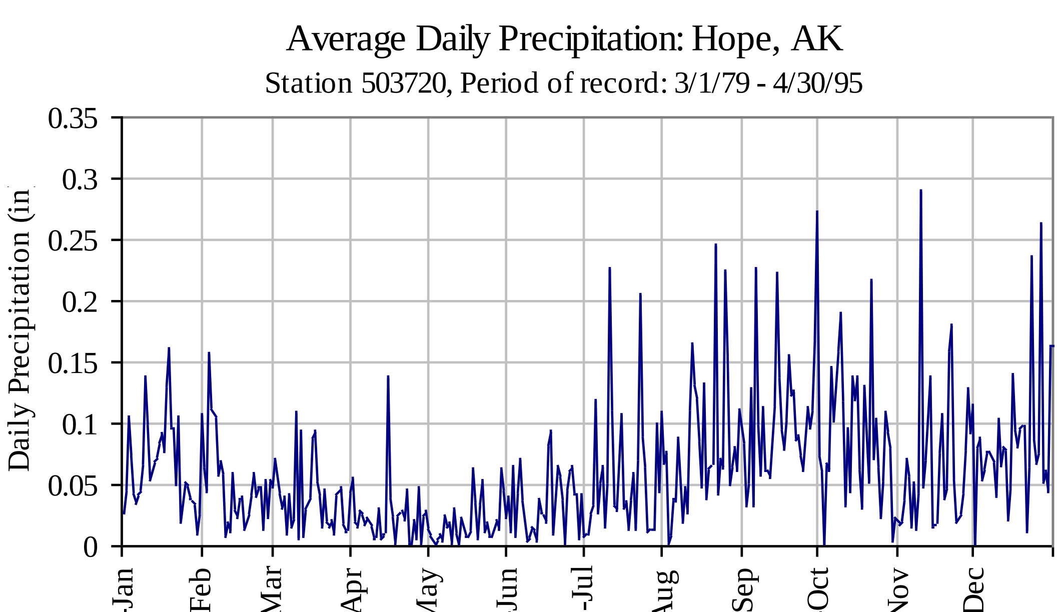


Table 2.II.A-3: SNOTEL and Snow Course data for sites within the Sixmile Creek watershed. Data from NRCS (2002). Snow water equivalent (SWE) is equal to the depth of water (in inches) in a column of snow.

Alaska SNOTEL Snow Water Equivalent (SWE) Averages: 1961-1990 (inches)														
SNOTEL site	Elev (ft)	Date	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Summit Creek	1400	1st	0	1.7	3.6	5.9	8.6	11	12.9	11	0	0	0	0
		15th	0.8	2.7	4.6	7.2	9.6	12	13.4	7.5	0	0	0	0
Turnagain Pass	1880	1st	0	4.5	10.6	17.3	23.8	29.2	34.2	38.6	26.5	0	0	0
		15th	0.8	7.5	13.9	20.5	26.5	31.7	37.7	36	4.5	0	0	0

Alaska Snow Course Snow Water Equivalent (SWE) Averages: 1961-1990 (inches)											
Snow Course	Elev (ft)	1-Jan		1-Feb		1-Mar		1-Apr		1-May	
		Depth	SWE	Depth	SWE	Depth	SWE	Depth	SWE	Depth	SWE
Bertha Creek	950	30	7.8	39	10.9	47	13.9	53	16.9	53	18.9
Kenai Summit	1390	32	6.9	39	9.6	44	12	45	13.9	34	12.1

Figure 2.II.A-5: SNOTEL and Snow Course data for sites within the Sixmile Creek watershed. Data from NRCS (2002).

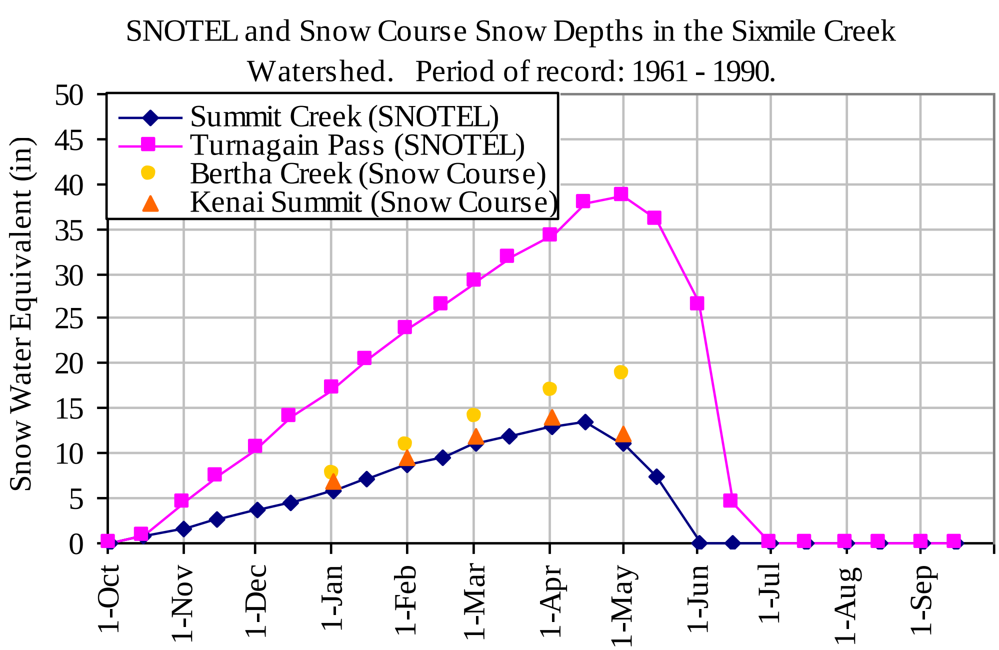
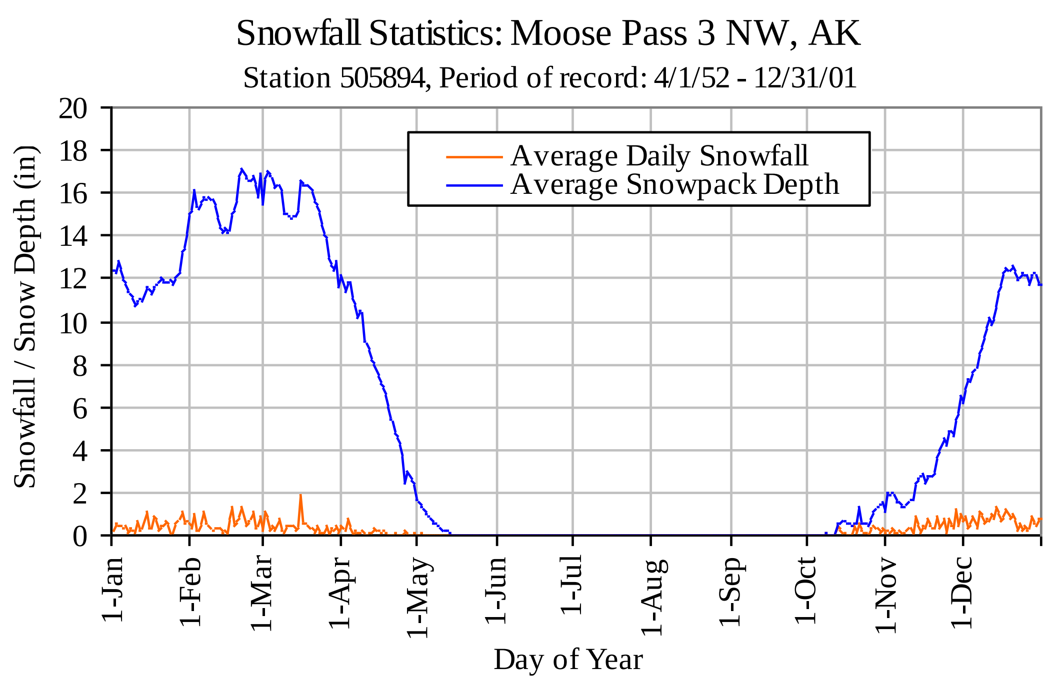
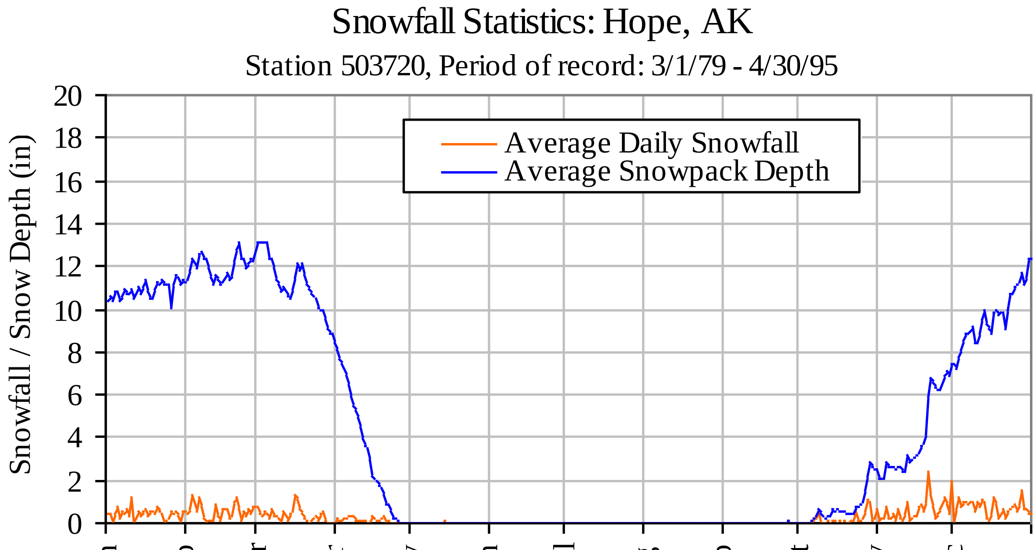


Figure 2.II.A-6: Snowfall statistics for Moose Pass 3 NW, AK (Station 505894) and Hope, AK (Station 503720). Data from WRCC (2002).





Moose Pass receives an average of 82.6 inches of snow per year with an average maximum snowpack of 16 inches occurring in February. Hope receives slightly more snow, with an average of 89.5 inches of snow per year. However, snowpack depths are shallower in Hope because of higher rates of melting and thawing during the winter. The average maximum snowpack in Hope is 12 inches, occurring in February.

4. Wind

Winds generally come from Prince William Sound in the east, although winds in this region are complex and variable, and winds generally increase above timberline. The US Forest Service collected wind data at Tincan Mountain on Turnagain Pass, located at 1880 feet in elevation, during the three winters from 1968 to 1972. Wind speeds averaged 5 mph during the day, and peak velocities reached 40 mph. These data showed no periods greater than 3 or 4 hours with wind speeds consistently above 15 mph (Blanchet, 1986). Mountain ridges receive much greater maximum winds, with gusts likely as high as 100 miles per hour.

B. Hydrology and Water Quality

1. Channel Character

a. Current Channel Conditions: After 1895

Canyon Creek: Much of Canyon Creek is incised into a narrow gorge at the bottom of a glacially carved valley. This deep canyon was created as Canyon Creek eroded downward to the level of the East Fork Sixmile Creek valley, a deeper valley carved by a larger glacier. Below the confluence with Mills Creek, all of Canyon Creek is classified as a Moderate Gradient Contained Narrow Valley Channel (LC2). This channel is confined by steep canyon walls and includes numerous waterfalls and cascades. Between Upper and Lower Summit Lakes, Canyon Creek is classified as a Narrow Low Gradient Flood Plain Channel (FP3), a sinuous, low gradient channel with low velocities and low sediment transport capacity. Upper and Lower Summit Lakes function as settling basins for sediments transported by the uppermost tributaries of Canyon Creek (**figure 2.II.B-1**), although most sediment input occurs downstream of these lakes.

Figure 2.II.B-1: Upper and Lower Summit Lakes, in the southern portion of the Canyon Creek watershed, looking toward the south.

Mills Creek is the largest tributary to Canyon Creek, flowing 11.8 miles from the southern end of the analysis area. The upper portion of Mills Creek is a Narrow Mixed Control Channel (MM1), and the lower portion is a Moderate Width Mixed Control Channel

(MM2). A large, active area of mass wasting exists within the Juneau Creek watershed, on the north side of Juneau Creek just upstream of its confluence with Mills Creek (**figure 2.II.B-2**). Seasonal high flows erode the toe of the steep, unstable slope. Spring freeze-thaw cycles and soil saturation from snowmelt in the upper layers of the slope cause mudflows into Juneau Creek. These mudflows transport a large amount of fine sediment into Juneau Creek, greatly increasing the turbidity of Mills Creek and Canyon Creek downstream.

Figure 2.II.B-2: View looking down steep eroding slope into Juneau Creek. This contributes considerable sediment to the channel during snowmelt and rainstorms.

East Fork Sixmile Creek: Because it occupies a large, glacially carved valley, East Fork Sixmile Creek is predominantly a Wide Low Gradient Flood Plain Channel (FP5) and has a lower overall gradient than Canyon Creek. However, upstream of the confluence with Canyon Creek, East Fork Sixmile Creek enters a small gorge and is classified as a Moderate Gradient Contained Narrow Valley Channel (LC2) and a Deeply Incised Contained Channel (MC3) (**figure 2.II.B-3**). East Fork Sixmile Creek has three significant tributaries. Granite Creek, originating on Turnagain Pass, and Bench Creek, originating on Johnson Pass, are both predominantly Low Gradient Flood Plain Channels (FP3, FP4, and FP5). Center Creek is a Low Gradient Flood Plain Channel in its lower reaches.

Sixmile Creek: The uppermost and lowermost portions of Sixmile Creek downstream of the confluence with Canyon Creek are Wide Low Gradient Flood Plain Channels (FP5). From Alder Creek to Falls Creek, Sixmile Creek contains 2 short gorges, classified as

Deeply Incised Contained Channels (MC3) and Moderate Gradient Contained Narrow Valley Channels (LC2). These bedrock gorges are incised into the bottom of the glacially carved Sixmile valley. These canyons provide recreational opportunities for whitewater boating, as they contain small waterfalls, cascades, and boulder runs.

Figure 2.II.B-3: East Fork Sixmile Creek gorge, near Gulch Creek.

b. Human influences on channel morphology

Placer mining activity has had a significant impact on stream morphology, water quality, habitat, and riparian vegetation. Historic placer mining in the Sixmile Creek watershed included the use of hydraulic mining techniques, as well as steam shovels and other heavy mining equipment. Hydraulic mines used high pressure water jets to remove soils, vegetation, and overburden from "pay" gravels often located adjacent to streams. This mining technique can be particularly damaging to a stream channel and its floodplain. Placer mining removed fine sediments from streambanks, leaving gravel and cobbles, which do not easily support new vegetative growth. These operations also straightened channels and removed large woody debris, decreasing channel complexity in many stream reaches. Hydraulic mining was used historically, between 1903 and 1940, on a number of streams, including Sixmile Creek, Canyon Creek, Mills Creek, Juneau Creek, Bertha Creek, Lynx Creek, and other area streams. Hydraulic mining impacts on parts of Sixmile Creek and Mills Creek remain very apparent almost a century later, and many damaged channels have not been rehabilitated. A momentary surge in gold mining operations, particularly heavy equipment placer operations, occurred in 1980 and 1981 because of high gold prices.

As well as the direct effects of mining along stream channels, hydraulic mining usually involved the construction of extensive contour ditches along mountain slopes. These ditches were used to transport water to a location sometimes several hundred feet above the mining area so that adequate water pressure could be obtained. After mining, these ditches generally fell into disrepair, but they still currently function to disrupt, divert, and concentrate runoff flows along the mountainsides where the ditches are located. In some cases this has caused mass wasting along the ditch line and erosion along new slope channels.

Present placer mining within the analysis area is accomplished primarily using small suction dredges. When used in stream channels, these dredges have limited impacts on the channel morphology. However, when used to cut into streambanks, particularly if the dredge is reversed into a hydraulic mode, these dredges can cause significant bank damage and stream sedimentation. The effects of present mining are insignificant compared to those of historic mining operations on Sixmile Creek, Canyon Creek, and Mills Creek.

No data have been collected quantifying bank stability or floodplain integrity on Sixmile Creek or Mills Creek. However, qualitative assessments of bank stability and the condition of impaired floodplains associated with the effects of historic large-scale mining operations have been conducted on these streams. For the purpose of analysis, current conditions of bank stability and floodplain integrity are considered to be those currently found in areas that have been extensively mined on Sixmile Creek and Mills Creek. Localized areas of bank erosion and unvegetated banks are common in historically placer mined areas, and mine tailings adjacent to channels have significantly altered the banks. Mine tailings exist in many floodplains in these historically placer mined areas, resulting in non-functional floodplains and constrained channel flows.

Canyon Creek: Between 1898 and 1912, the Agra Mining Company and the Eldorado Company extensively mined six miles of Canyon Creek (**figure 2.II.B-4**). They established a network of ditches around the confluence of Canyon Creek and East Fork Sixmile Creek to supply water for hydraulic mining. The Canyon Creek Development Company (CCDC) established 18 placer claims on Canyon Creek in 1912 and 2 claims on

Canyon Creek in 1914 and 1915. By 1925, CCDC had constructed a 70-foot high dam near the mouth of Canyon Creek in order to access an ancient channel downstream and provide a head of water for hydraulic mining. Mining continued through the 1920's and 1930's. By 1955, a pipeline supplied water from Fresno Creek for hydraulic mining between miles 48 and 50 on the Seward Highway, and a dragline operation was established by 1963. Placer mining claims are also widespread on Mills Creek, Juneau Creek, Colorado Creek, Frenchy Creek, Block Creek, Roaring Creek, and Timberline Creek. Lode mines were located in the drainages of Frenchy Creek, Colorado Creek, Fresno Creek, and Juneau Creek. Currently, the Alaska Department of Transportation operates a gravel pit to the east of the Seward Highway at milepost 49, approximately one mile north of the outlet of lower Summit Lake (**figure 2.II.B-5**).

The Polly Mine claims, located on Mills Creek between its mouth and Juneau Creek, were established in 1895. The Seward Placer Corporation, Moose Pass Placers, Inc., and other mining companies made extensive hydraulic mining efforts in Mills Creek between 1932 and 1938. After a dormant period, mining briefly resumed in the late 1950's. Mills Creek is currently mined, but the effects of present mining are insignificant compared to the changes in channel morphology resulting from the large-scale mining efforts of the early 20th century. Placer mining in Mills Creek resulted in eroding banks, tailings piles within the floodplain, and a loss of riparian vegetation. The portion of Mills Creek that was most affected by mining is the half-mile long low-gradient section just upstream of the Canyon Creek confluence (**figure 2.II.B-5**).

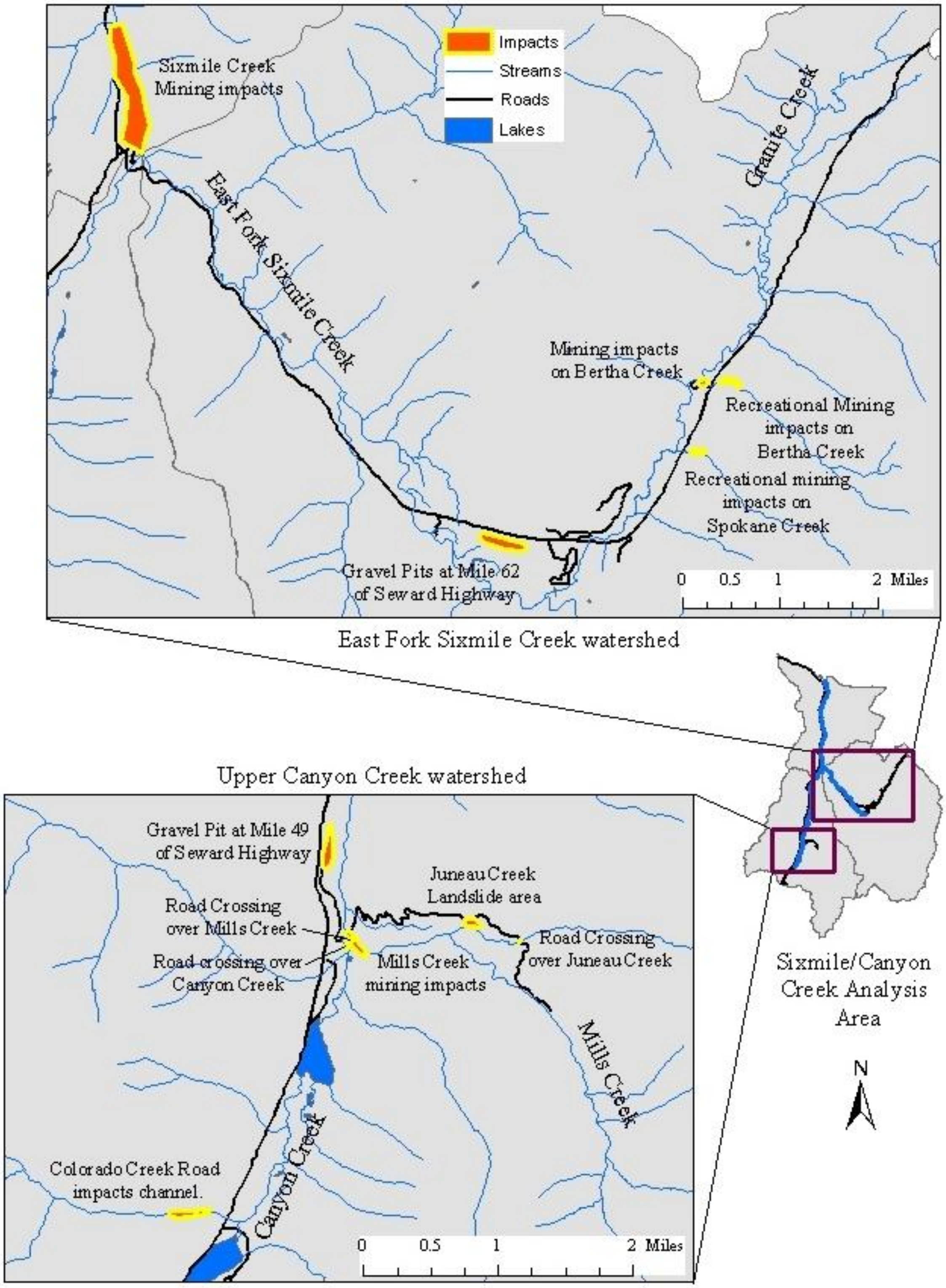
Figure 2.II.B-4: Placer mined channel of Canyon Creek.

Short access roads extend to Mills Creek and Tenderfoot Campground near Summit Lake. The Mills Creek road includes un-bridged stream crossings of Canyon, Mills, and Juneau

Creeks, resulting in channel widening and bank degradation at these crossings. Non-system roads exist throughout the watershed, and many of these unmaintained roads are in poor condition. The short non-system road that runs adjacent to Colorado Creek is in poor condition, eroding and capturing streamflows on the alluvial fan of Colorado Creek. Non-system roads also access Canyon Creek at Mile 50 and 52 from the Seward Highway and cabins north of lower Summit Lake. Many short roads constructed by Chugach Electric Association, Inc. provide access for maintenance of the powerlines that parallel the Seward and Hope Highways, on the west side from Hope to Summit Lake, and along the Seward Highway over Turnagain Pass. Although they receive limited use, many of these roads cross wetlands and streams, and their generally poor condition causes erosion. Summer OHV use leads to further damage. **Figure 2.II.B-5** shows the locations of road segments that have had significant impacts on streams.

East Fork Sixmile Creek: Placer mine claims in the East Fork Sixmile Creek watershed are located on Gulch Creek, Silvertip Creek, Lynx Creek, Spokane Creek, Bertha Creek, Groundhog Creek, Bench Creek, Lyon Creek, and Tincan Creek. Bertha Creek was extensively mined in the present location of the campground (**figure 2.II.B-5**). Placer mines on Silvertip Creek used small suction dredges, as well as a dozer-fed sluice (Blanchet, 1981). Lynx Creek was hydraulically mined in the early 1900's and more recently in 1980. The 1980 operation used two hydraulic giants. Water from Lynx Creek was piped from upstream to hydraulically mine a 100-foot high bank within the Lynx Creek canyon, causing considerable change in the channel morphology. No settling ponds were constructed, and as a result of sedimentation, the downstream channel became shallower and wider. The mine operator then diverted Lynx Creek through the forest to the west to allow this sediment to settle out upstream of the confluence with East Fork Sixmile Creek, but this caused considerable erosion and damage to the forest (Blanchet, 1981). A series of gravel pit mines are located along East Fork Sixmile Creek near Granite Creek Campground at mile 62 of the Seward Highway (**figure 2.II.B-5**). Gravel from these pits is predominantly used for road construction on the Seward Highway, and efforts are underway to restore these pits into wetland ponds.

Figure 2.II.B-5: Locations of disturbed areas in the Sixmile/Canyon Creek analysis area, representing significant impacts of placer mines, gravel mines, roads, and landslides.



Impacts
Streams
Roads
Lakes
Sixmile Creek
Mining impacts
East Fork Sixmile Creek
Granite Creek
Mining impacts
on Bertha Creek
Recreational Mining
impacts on
Bertha Creek
Recreational mining
impacts on
Spokane Creek
Gravel Pits at Mile 62
of Seward Highway
0 0.5 1 2 Miles
East Fork Sixmile Creek watershed
Upper Canyon Creek watershed
Gravel Pit at Mile 49
of Seward Highway
Juneau Creek
Landslide area
Road Crossing
over Mills Creek
Road Crossing
over Juneau Creek
Road crossing over
Canyon Creek
Mills Creek
mining impacts
Mills Creek
Canyon Creek
Colorado Creek Road
impacts channel.
0 0.5 1 2 Miles
Sixmile/Canyon
Creek Analysis
Area
N

Sixmile Creek is a proposed Wild and Scenic River for its recreational values. East Fork Sixmile Creek and Lower Sixmile Creek are popular kayaking and commercial whitewater rafting streams. These streams receive considerable use from June to August, with over 1800 rafters and kayakers running Sixmile Creek each year (USDA Forest Service, Alaska Region, 1996). This has contributed to some bank degradation and loss of riparian vegetation at river access points. Canyon Creek and Granite Creek also receive occasional use from whitewater boaters. Recreational gold mining is conducted on federal lands in the Sixmile Creek watershed. Recreational miners use gold pans, sluice boxes, and suction dredges. These activities have slight impacts on channel morphology and water quality. Recreational mining on Bertha Creek and Spokane Creek has led to bank erosion in these channels upstream of the Seward Highway (**figure 2.II.B-5**).

Sixmile Creek: Placer mine claims in the lower Sixmile Creek watershed are located on Sixmile Creek, Falls Creek, and a small tributary to Sixmile Creek. The first 2 miles of Sixmile Creek downstream of the Canyon Creek confluence (**figure 2.II.B-5**) were extensively dredged during past mining operations, resulting in eroding banks, tailings piles within the floodplain, channelized flow, and a loss of channel complexity. Much of this area has been naturally revegetated. Although much of the west floodplain of Sixmile Creek at this location was affected, many portions of this area have been naturally revegetated.

c. Reference conditions: Before 1895

For the purpose of analysis, reference conditions for channel morphology parameters are considered to be those portions of Sixmile Creek and Mills Creek that have not been influenced by placer mining or other human activities. No data are available quantifying historic bank stability of floodplain integrity on Sixmile Creek or Mills Creek. However, qualitative observations of bank stability and the condition of floodplains in stream reaches that were unaffected by mining or other human influences in these streams have been made. These unaffected stream banks are generally stable and are vegetated with large woody debris often present. The banks contribute to some degree of channel complexity. However, channel migration may occur naturally during high flows, causing some natural bank erosion. Unaffected floodplains are functional and well vegetated. High flows are able to move into the floodplain, and some natural channel migration may occur during these floods.

d. Interpretations of change

Bank stability – Bank stability in historically placer-mined areas of Sixmile Creek and Mills Creek has worsened as a result of past placer mining operations. This represents a substantial change from reference conditions, but affected reaches are limited to specific, isolated mining areas (**figure 2.II.B-5**). Many of these banks consist of material worked by miners, which consists predominantly of the gravel and cobbles that remain after dredging. These tailings piles and the eroding banks created by some large-scale mining activities are unvegetated, and natural processes have not healed them. Tailings piles along the banks channelize flow in these streams. Bank rehabilitation projects would likely improve the condition of these banks, help establish healthy riparian vegetation, and reduce sediment input into these streams. This would also improve aquatic habitat.

Floodplain integrity: The presence of mine tailings and the effects of historic placer mining operations in the floodplains of Sixmile Creek and Mills Creek have altered the natural function of these floodplains. This represents a substantial change from reference conditions, but affected floodplains are limited to only those in specific, isolated mining areas (**figure 2.II.B-5**). In areas that were historically placer-mined, mining operations removed much of the riparian vegetation and left large tailings piles consisting predominantly of gravel and cobbles, which do not readily support vegetation. Tailings left along the stream banks channelize the flow and do not allow flood flows to move into the natural floodplain. Although flood flows on Sixmile Creek are capable of transporting some of these tailings, natural processes have not healed these floodplains. Floodplain rehabilitation projects would likely restore the functionality of these floodplains. This would also enhance aquatic and terrestrial habitats, improve water quality, and decrease flood conveyance.

2. Streamflows

Sixmile Creek is monitored by a US Geological Survey (USGS) gauging station, located about 3 miles north of the confluence with Canyon Creek, and 24 years of historical flow data, in addition to realtime data, are available from this site. Four streams in the Sixmile Creek watershed (Cub, Donaldson, Fresno, and Granite Creeks) have historical flow data from USGS gauges, although these gauges only recorded peak flows. Metadata for these gauging stations are presented in **table 2.II.B-1,** and stream gauge locations are depicted in **figure 2.II.A-1**.

Table 2.II.B-1: Metadata for USGS gauging stations in the Sixmile/Canyon Creek analysis area. Data from USGS (2002).

Station	USGS Site#	Latitude	Longitude	Elev (ft)	Datum	Drainage area (sq mi)
Sixmile Cr Nr Hope AK	15271000	60°49'15"	149°25'31"	250	NAD27	234
Cub Cr Nr Hope AK	15271900	60°52'12"	149°26'02"	300	NAD27	1.8
Donaldson Cr Nr Wibel AK	15270400	60°45'40"	149°27'20"	700	NAD27	4.07
Fresno Cr Nr Sunrise AK	15270100	60°40'15"	149°28'35"	1,250	NAD27	6.03
Granite Cr Nr Portage AK	15269500	60°43'40"	149°17'00"	700	NAD27	28.2

	Period of Record (number of records)		
Station	Peak Streamflow	Daily Streamflow	Water Quality Samples
Sixmile Cr Nr Hope AK	10/01/69 - 06/08/00 (15)	06/01/79 – 09/30/90 and 10/01/97 – 09/30/00 (5298)	01/11/89 - 05/15/89 (2)
Cub Cr Nr Hope AK	01/01/65 - 09/20/95 (16)		10/06/71 - 09/14/78 (3)
Donaldson Cr Nr Wibel AK	07/01/63 - 05/01/72 (10)		11/12/71 - 10/05/72 (2)
Fresno Cr Nr Sunrise AK	07/01/63 - 10/06/69 (8)		11/13/51 - 11/13/51 (1)
Granite Cr Nr Portage AK	10/01/66 - 09/20/95 (15)		05/21/52 - 08/20/58 (13)

Increased glacial melting and variations in precipitation likely have caused some minor fluctuations in flow regime during the past century, but flow records are not available before 1963. Recent tree mortality from the spruce bark beetle infestation may result in a decrease in evapotranspiration rates. This could possibly lead to increased runoff volume and altered flow regimes, although spruce-forested areas cover only a small portion of the watershed. Abundant understory growth in these affected forests may also cause evapotranspiration rates to remain relatively high, despite the loss of the larger spruce trees.

a. Sixmile Creek

Streamflows in the Sixmile Creek watershed are largely dominated by snowmelt runoff, although rainfall also has an effect on the hydrograph. The peak of snowmelt runoff is an extended event that generally lasts about a month, beginning in early June. Rainstorm peaks, which are frequent in the fall but smaller than the snowmelt peak, generally last only one to two days. Because of the longer duration of the snowmelt runoff, the snowmelt peak moves a much larger sediment load than the rainfall peak and is the primary channel-forming event. However, large rainstorms that occur during the snowmelt peak create the potential for extreme high flows. Because there are no large glaciers in the watershed, glacial melting has only a moderate effect on the hydrograph, prolonging the snowmelt peak slightly later into the summer.

Flow statistics for Sixmile Creek are compiled in **table 2.II.B-2**. Elevated summer flows usually begin in early May and persist until the end of October (**figure 2.II.B-6**). The month of May experiences rapid increases in flow during the initial snowmelt runoff. The snowmelt peak occurs between early June and early July, with average peak flows ranging from 2500 to 3000 cubic feet per second (cfs). The extreme high flow of 8070 cfs recorded on July 12, 1980 was likely the result of heavy rainfall that occurred during snowmelt runoff. August, September, and October receive considerably more precipitation in the form of rain, creating the potential for high streamflows. A secondary peak resulting from seasonal rainfall occurs on average in early October, with average peak flows of 1000 to 1500 cfs, but short-term peak flows can range from 2000 to 6000 cfs. Winter base flows remain low, at about 200 cfs, throughout the winter because most of the streams throughout the watershed are covered with snow and ice. Winter ice jams can cause localized flooding, and moving ice can affect channel morphology.

Figure 2.II.B-6: Average daily streamflows for Sixmile Creek. Period of record 06/01/79 to 9/30/90 and 10/1/97 to 09/30/00 (USGS, 2002)

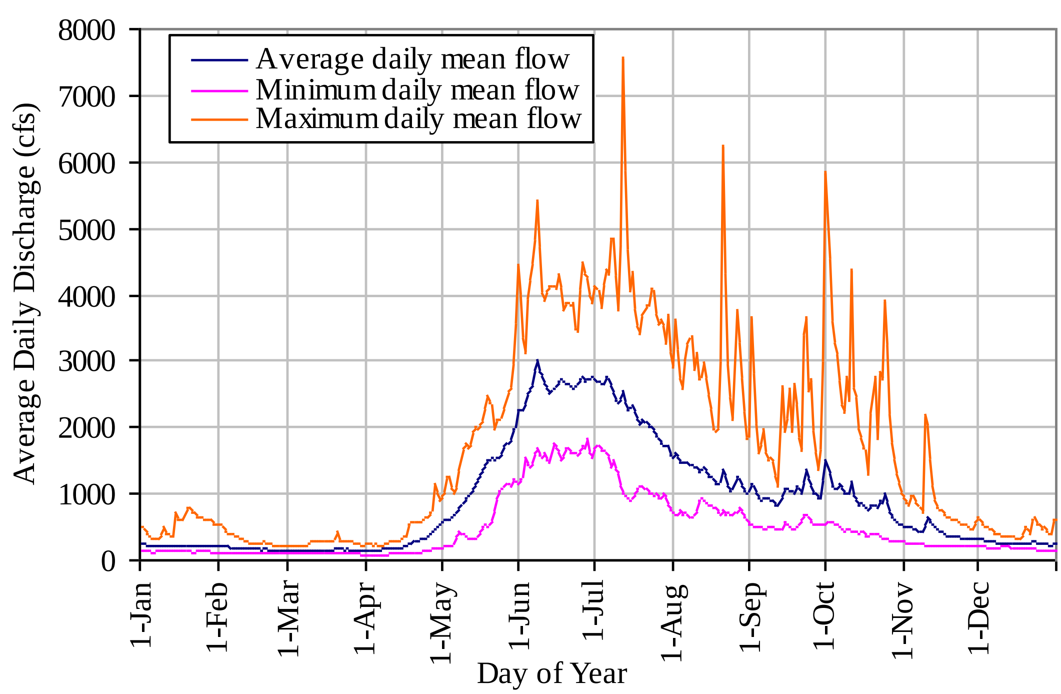


Table 2.II.B-2: Daily streamflow statistics for Sixmile Creek (station # 15271000), compiled from gauging station data from USGS (2002). Recurrence interval flows based on flood frequency analysis of historical station data using weighted skew (USGS, 1994).

Sixmile Creek near Hope, AK	
Average daily flow	929 cfs
Extreme minimum daily flow	80 cfs (on 4/1/86 – 4/9/86)
Record instantaneous peak flow	8070 cfs (on 7/12/80)
Median annual peak flow (Q_2)	4840 cfs
Flow per square mile (for median annual peak flow)	20.7 cfs / sq mi
10-year peak flow (Q_{10})	7450 cfs
Flow per square mile (for 10-year peak flow)	31.8 cfs / sq mi

b. Other flow data

Although Canyon Creek includes approximately 1/3 of the drainage area represented by the stream gauge on Sixmile Creek, its flow likely comprises less than 1/3 of the total flow into Sixmile Creek because of the dramatic differences in precipitation across the Sixmile Creek watershed. No stream flow gauges exist on Canyon Creek itself, but two tributaries, Fresno Creek and Donaldson Creek, have historic peak flow measurements from USGS gauging stations (**table 2.II.B-3**).

In a hydrologic study for the Seward Highway bridge over Canyon Creek, George C. Schwaderer, Inc. (1994) used the Central Alaska Region II regression equations (USGS, 1994), calibrated using flow data from Resurrection Creek, to estimate flood flows for Canyon Creek (**table 2.II.B-3**). They determined that Canyon Creek, with a drainage area of 96.75 square miles, has an estimated median annual flow (Q_2) of 628 cfs. Additional peak flow data are also available from USGS gauging stations on Fresno Creek and

Donaldson Creek in the Canyon Creek watershed; Cub Creek, flowing into lower Sixmile Creek; and Granite Creek, flowing from Turnagain Pass into East Fork Sixmile Creek (**table 2.II.B-3**). The peak flows per square mile in Granite Creek are somewhat higher than those measured in Canyon, Fresno, Donaldson, and Cub Creeks. This suggests that runoff increases toward the eastern portion of the watershed, as would be expected from precipitation trends.

Table 2.II.B-3: Peak flow data for tributary streams in the Sixmile Creek watershed. Canyon Creek data from George C. Schwaderer, Inc. (1994), based on USGS flood frequency analysis regression equations. Other stream data from USGS (2002) historical flow records. Recurrence interval flows based on flood frequency analysis of historical station data using weighted skew (USGS, 1994).

		USGS peak flow gauging stations			
	Canyon Creek (estimated)	**Fresno Creek** (15270100)	**Donaldson Creek** (15270400)	**Cub Creek** (15271900)	**Granite Creek** (15269500)
Drainage area (sq mi)	96.75	6.03	4.07	1.8	28.2
Number of years of record	0	8	10	16	15
Maximum peak flow (cfs)	-	135	170	54	2040
Minimum peak flow (cfs)	-	42	22	9	350
Median annual peak flow (Q_2) (cfs)	628	81	67	29	1010
Flow per square mile for median annual flow (cfs/sq mi)	6.5	13.4	16.5	16.1	35.8
10-year peak flow (Q_{10}) (cfs)	1329	111	140	46	1890
Flow per square mile for 10-year peak flow (cfs / sq mi)	13.7	18.4	34.4	25.6	67.0

3. Water Quality

a. Current Conditions: After 1895

Water quality data sites are located throughout the Sixmile/Canyon Creek analysis area. These sites include USGS gauging stations and water quality sample stations, as well as several locations studied by the US Forest Service. Metadata for these sites are presented in **table 2.II.B-4,** and locations of water quality data sites are shown in **figure 2.II.A-1**.

Table 2.II.B-4: Station metadata for water quality sampling sites in the Sixmile/Canyon Creek analysis area.

Station	USGS Site# or Data source	Location			Period of record (Number of records)
		Latitude	Longitude	Datum	
Summit Lk Nr Cooper Landing AK	603830149293000	60°38'30"	149°29'30"	NAD27	05/30/75 - 05/30/75 (1)
EF Sixmile Cr Nr Sunrise AK	604355149201800	60°43'55"	149°20'18"	NAD27	11/13/51 - 08/06/53 (10)
Silvertip Cr Nr Sunrise AK	604420149213000	60°44'20"	149°21'30"	NAD27	11/13/51 - 08/09/55 (4)
Spokane Cr Nr Sunrise AK	604436149152400	60°44'36"	149°15'24"	NAD27	06/20/52 - 06/20/52 (1)
Bertha Cr Nr Portage AK	604503149145500	60°45'03"	149°14'55"	NAD27	08/07/53 - 08/07/53 (1)
Gulch Cr Nr Sunrise AK	604636149234800	60°46'36"	149°23'48"	NAD27	11/13/51 - 11/13/51 (1)
Canyon Cr Nr Sunrise AK	604650149253600	60°46'50"	149°25'36"	NAD27	04/22/52 - 08/20/58 (14)
Sixmile Cr Nr Hope AK	15271000	60°49'15"	149°25'31"	NAD27	01/11/89 - 05/15/89 (2)
Cub Cr Nr Hope AK	15271900	60°52'12"	149°26'02"	NAD27	10/06/71 - 09/14/78 (3)
Donaldson Cr Nr Wibel AK	15270400	60°45'40"	149°27'20"	NAD27	11/12/71 - 10/05/72 (2)
Fresno Cr Nr Sunrise AK	15270100	60°40'15"	149°28'35"	NAD27	11/13/51 - 11/13/51 (1)
Granite Cr Nr Portage AK	15269500	60°43'40"	149°17'00"	NAD27	05/21/52 - 08/20/58 (13)
Mills Cr. Devel. Co. Claim (2 sites)	Blanchet (1981)	Above/below mining			8/15/80; 9/17/80 (5)
Silvertip Cr. placer claims (2 sites)	Blanchet (1981)	Above/below mining			6/16/80 - 9/19/80 (4)
Lynx Creek placer mine (3 sites)	Blanchet (1981)	Above/below mining			7/20/80; 8/14/80 (4)
Mills Creek and Canyon Creek (3 sites)	Huber and Blanchet (1992)	Mills/Canyon Cr confluence; Canyon/EF Sixmile confluence			6/29/88 - 8/26/90 (94)
Mills Creek at Mills Creek Mine (2 sites)	Ecology and Envir. (1995)	Upstream and downstream of Mills Creek Mine			7/28/94 (2)

Canyon Creek watershed: Mills Creek contributes considerable sediment and numerous pollutants to Canyon Creek and Sixmile Creek further downstream. Sediment is derived from the large eroding hillslope adjacent to the lower portion of Juneau Creek. Additional sediment as well as heavy metals are derived from mining operations on Mills Creek (**figure 2.II.B-7**).

Figure 2.II.B-7: Confluence of Mills Creek and Canyon Creek. Mills Creek, in the background, is significantly more turbid.

In 1980, water quality data were collected upstream and downstream of the Mills Creek Development Company claim located on Mills Creek at approximately 1500 feet in elevation (Blanchet, 1981) (**table 2.II.B-5**). These water quality data include physical water quality parameters as well as heavy metal concentrations. Silt loads in Mills Creek are naturally elevated, the result of sediment input from the movement of small glaciers near the headwaters, but turbidity can also be affected by placer mining operations. Turbidities measured upstream and downstream of the Mills Creek Development Company Claim in 1980 indicate that at times, Mills creek carried more sediment downstream of the mining, even though this site used a relatively efficient pair of settling ponds to remove sediment from the water. One pair of samples shows an increase in turbidity from 2.7 NTU upstream of the mining to 29 NTU downstream of the mining. This increase of 26 NTU exceeds the state standard that allows for no more than a 25 NTU increase above natural levels in fish-bearing streams (ADEC, 1999).

Increases as well as decreases in trace and heavy metal concentrations occurred between upstream and downstream sites on Mills Creek. Lead concentrations measured on September 17, 1980 showed an increase from 0.03 mg/L upstream of the mining to 0.07 mg/L downstream of the mining. The latter measurement exceeded the state standard of

0.05 mg/L for Lead. Selenium concentrations, measuring 0.09 mg/L for all samples, also exceeded the state standard of 0.01 mg/L, although these measured concentrations are suspect because of questionable analysis techniques (Blanchet, 1981). Although standards have not been developed for many of the measured parameters, no other parameters exceeded the state standards. However, the data show notable increases in concentrations related to the mining activity for Zinc, Manganese, Iron, Molybdenum, and Aluminum. Additional heavy metal water quality data were collected in 1994 from Mills Creek upstream and downstream of the Mills Creek Mine (Ecology and Environment, 1995) (**table 2.II.B-6**). These data show no abnormally high concentrations.

Table 2.II.B-5: Water quality parameters recorded at Mills Creek Development Company Claim. Data from Chugach National Forest (Blanchet, 1981).

Location	Date	Time	Discharge (cfs)	Turbidity (NTU)	Suspended Solids (mg/L)	Specific Conductivity (mS/cm)	Water Temp (°C)	Air Temperature (°C)	Dissolved Oxygen (ppm)	pH	Zinc (mg/L)	Manganese (mg/L)	Iron (mg/L)	Copper (mg/L)	Nickel (mg/L)
Above Mining	8/15/80	1200	233	2.7	2.8	71	4	9	12.7	7.7	0.075	0.002	0.008	0.01	<0.01
Below Mining	8/15/80	1100	233	29	85.5	71	3.5	9	12.8	7.6	0.06	0.035	0.079	0.017	0.01
Below Mining	8/15/80	1315	233	22	37.9					7.4	0.06	0.007	0.008	0.01	<0.01
Above Mining	9/17/80	1415	190	1.9	5.7	70	5	14		7.2	0.032	0.002	0.004	0.005	<0.01
Below Mining	9/17/80	1620	190	6.5	20.1	71	5	12		7.1	0.116	0.008	0.004	0.01	<0.01

Location	Date	Time	Cadmium (mg/L)	Lead (mg/L)	Arsenic (mg/L)	Chromium (mg/L)	Molybdenum (mg/L)	Strontium (mg/L)	Selenium (mg/L)	Zirconium (mg/L)	Antimony (mg/L)	Cobalt (mg/L)	Aluminum (mg/L)	Boron (mg/L)	Vanadium (mg/L)
Above Mining	8/15/80	1200	0.003	0.03	<0.01	0.008	<0.10	0.06	0.09	0.02	0.08	0.07	0.06	0.009	0.01
Below Mining	8/15/80	1100	0.004	0.03	0.02	0.012	0.26	0.06	0.09	0.02	0.05	0.12	0.22	0.025	0.01
Below Mining	8/15/80	1315	0.002	0.03	0.02	0.01	0.21	0.06	0.09	0.02	0.05	0.09	0.06	0.009	0.01
Above Mining	9/17/80	1415	0.002	0.03	0.02	0.012	0.17	0.06	0.09	0.01	0.05	0.04	0.04	0.015	0.01
Below Mining	9/17/80	1620	0.004	0.07	0.01	0.011	0.2	0.06	0.09	0.02	0.08	0.09	0.06	0.009	0.012

Table 2.II.B-6: Water quality data for Mills Creek at Mills Creek Mine. Data from Ecology and Environment, Inc. (1995).

Location	Date	Time	Zinc (mg/L)	Copper (mg/L)	Lead (mg/L)	Arsenic (mg/L)
Above Mining	7/28/94	1610	0.025	0.025	0.005	0.005
Below Mining	7/28/94	1705	0.025	0.025	0.005	0.0082

Water quality data were collected at three sites between 1988 and 1990 to determine possible effects of placer mining on water quality (Huber and Blanchet, 1992*)* (**table 2.II.B-7**). These sites included 1) Mills Creek just upstream of its confluence with Canyon Creek (24 samples), 2) Canyon Creek just downstream of Mills Creek (35 samples), and 3) Canyon Creek just upstream of its confluence with East Fork Sixmile Creek (35 samples). The lower Canyon Creek site is downstream of numerous suction dredge mining operations on Canyon Creek. Mining operations appear to have had little influence upon the measured parameters, and all values are within the natural range of variation. However, the data show that both turbidity and total suspended solids are higher in Mills Creek than in Canyon Creek. This shows that turbidity concentrations dissipate downstream in Canyon Creek, as would be expected with the addition of clear water from tributaries.

Table 2.II.B-7: Physical water quality parameters recorded in Mills and Canyon Creeks, 1988-1990. Data from Huber and Blanchet (1992).

Location	pH			Turbidity (NTU)			Alkalinity (mg/L)			Total Suspended Solids (mg/L)			Specific Conductance (mohms/cm)		
	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.
Mills Creek	6.91	7.42	7.81	0.55	3.19	23	13	20	27	0	3.76	24.4	52.3	61.6	74.7
Canyon Creek at Mills Creek	7.08	7.44	7.84	0.32	2.36	22	15	23	30	0	2.22	20.2	51	63.1	75.6
Canyon Creek at EF Sixmile	7.16	7.48	7.8	0.71	1.85	5	18	23	30	0	2.84	10.9	52.9	63.2	75.6

USGS water quality data were collected on Canyon Creek between 1952 and 1958 (USGS, 2002) (**table 2.II.B-8**). Low pH levels of 6.1 and 5.9, recorded on 7/16/58 and 5/21/58, violated the state standard of 6.5 for wildlife and public water systems (ADEC, 1999). These data show no other water quality anomalies for Canyon Creek. Single water quality samples were also collected for Fresno and Donaldson Creeks, as well as Summit Lake (USGS, 2002). No parameters recorded at these locations were in violation of state standards, and no recent water quality data exist for these USGS sites.

Sixmile Creek and East Fork Sixmile Creek watersheds: Silvertip Creek is the site of several placer claims that were mined by suction dredges and dozer-fed sluicing. Settling ponds were located downstream of the mining, and during sampling by the Chugach National Forest in 1980, miners were not creating large increases in turbidity downstream of the mining (Blanchet, 1981) (**table 2.II.B-9**). In 1980, Lynx Creek was the site of a hydraulic mining operation that used two hydraulic giants to mine a 100-foot high vertical bank in the Lynx Creek canyon. This operation caused great damage to the channel morphology, no settling ponds were used, and significant sedimentation occurred downstream. Water quality data collected by the Chugach National Forest in 1980 show large increases in turbidity and sediment loads downstream of the mining (Blanchet, 1981) (**table 2.II.B-9**).

Several streams in the East Fork Sixmile Creek and lower Sixmile Creek watersheds have a limited amount of water quality data from USGS sites, with measurements taken between 1951 and 1989 (**table 2.II.B-8)**. These data show that pH levels in East Fork Sixmile Creek and Granite Creek were occasionally below the state limit of 6.5, although these were isolated occurrences. Water quality data for Sixmile Creek, Cub Creek, Silvertip Creek, Spokane Creek, Bertha Creek, and Gulch Creek are all within state standards.

Table 2.II.B-8: Available USGS water quality data for streams and lakes in the Sixmile/Canyon Creek analysis area. Data from USGS (2002).

See Excel file: Sixmile_LA_WQ_Table.xls
(Prints on 11X17 sheet)

Table 2.II.B-9: Water quality parameters recorded at Silvertip Creek and Lynx Creek, 1980. Data from Chugach National Forest (Blanchet, 1981).

Location	Date	Time	Discharge (cfs)	Turbidity (NTU)	Suspended Solids (mg/L)	Specific Conductivity (mS/cm)	Water Temp (°C)	Air Temperature (°C)	Dissolved Oxygen (ppm)	pH	Zinc (mg/L)	Manganese (mg/L)	Iron (mg/L)	Copper (mg/L)	Nickel (mg/L)
Silvertip Creek															
Below mining	6/16/80	1430	96.8		4.2	71	3.3	25	11.2	7.2					
Above mining	7/20/80	1540	100	2.3	7.7	58	3	13.5	12.4						
Below mining	7/20/80	1650	136	5	19.6	62	3.5	16.5	12.6						
Below mining	9/19/80	1200	30.4	0.5	1	85	5	12			0.027	0.001	0.004	0.007	<0.01
Lynx Creek															
Above mining	7/20/80	1130	154	9	36	69	4.5	16	12.4		0.017	<.005	0.005	0.008	<.04
Wash water	7/20/80	1040	12.8	37	3560	60	4.5	16	12.4		<.005	<.005	0.007	<.005	<.04
Above mining	8/14/80	1630	70	1.5	7.5	80	5.5	10	11.6	8.1	0.039	0.004	0.004	0.007	<.01
Below mining	8/14/80	1510	74.1	26	99.2	78	6.5	11	11.9	7.9	0.025	0.004	0.004	0.01	<.01

Location	Date	Time	Cadmium (mg/L)	Lead (mg/L)	Arsenic (mg/L)	Chromium (mg/L)	Molybdenum (mg/L)	Strontium (mg/L)	Selenium (mg/L)	Zirconium (mg/L)	Antimony (mg/L)	Cobalt (mg/L)	Aluminum (mg/L)	Boron (mg/L)	Vanadium (mg/L)
Silvertip Creek															
Below mining	6/16/80	1430													
Above mining	7/20/80	1540													
Below mining	7/20/80	1650													
Below mining	9/19/80	1200	0.001	0.03	0.02	0.01	0.2	0.071	0.09	0.014	0.05	0.04	0.04	0.012	0.01
Lynx Creek															
Above mining	7/20/80	1130	<.005	0.17	0.04	<.005	<.10	0.073	<.04	<.005	<.04	0.07	<.04	<.005	0.01
Wash water	7/20/80	1040	<.005	0.08	0.04	<.005	<.10	0.051	<.04	<.005	<.04	0.07	<.04	<.005	0.007
Above mining	8/14/80	1630	0.004	0.03	0.02	0.01	0.2	0.086	0.09	0.014	0.05	0.07	0.08	0.011	0.01
Below mining	8/14/80	1510	0.001	0.03	0.02	0.01	0.22	0.082	0.09	0.016	0.08	0.09	0.08	0.009	0.014

b. Effects of mining on water quality

A large amount of water quality data was collected for the extensively mined Mills Creek/Canyon Creek system, and conditions in these streams represent the effects of mining throughout the analysis area. Current conditions for water quality parameters are considered to be those measured in Mills Creek and Canyon Creek downstream of active mining sites over the last 25 years. The following selected factors were used to summarize current water quality conditions related to the effects of mining (**table 2.II.B-10**). Sources of information and assumptions are listed below.

Table 2.II.B-10: Current range of variability for significant factors.

Factor	Value
Trace and heavy metals – Lead	0.005 – 0.07 mg/L
Turbidity	0.71 – 29 NTU
Suspended solids	0.0 – 85.5 mg/L

Trace and heavy metals – Lead: A total of 3 samples from Mills Creek *downstream* of the Mills Creek Development Company mining claim were analyzed for trace and heavy metals in 1980 (Blanchet, 1981), and 1 sample was measured *downstream* of the Mills Creek Mine in 1994 (Ecology and Environment, 1995). A sample from 9/17/1980 with a lead concentration of 0.07 mg/L exceeded the 0.05 mg/L state water quality standard for lead.

Turbidity: A total of 3 samples from Mills Creek *downstream* of the Mills Creek Development Company mining claim were analyzed for turbidity in 1980 (Blanchet, 1981). These measurements recorded increases in turbidity downstream of the mining activity. Additionally, a total of 35 measurements for turbidity were recorded in Canyon Creek just upstream of the confluence with Sixmile Creek, *downstream* of numerous suction dredge sites, between 1988 and 1990 (Huber and Blanchet, 1992). These samples did not measure the impact from any particular mining activity, but the cumulative effects of multiple activities on Canyon Creek upstream of the sample location. It should be noted that the level of suction mining activity, if any, is unknown during the sampling period.

Suspended solids: A total of 3 samples from Mills Creek *downstream* of the Mills Creek Development Company mining claim were analyzed for suspended solids in 1980 (Blanchet, 1981). Additionally, a total of 35 samples were analyzed for suspended solids on Canyon Creek just upstream of the confluence with Sixmile Creek, *downstream* of numerous mining operations (Huber and Blanchet, 1992).

c. Reference conditions: Before 1895

For the purpose of analysis, water quality data collected upstream of active mining sites on Mills Creek and Canyon Creek are considered to be reference conditions. Reference values are the conditions that would be expected if the system were operating without significant human influence. The following selected factors were used to summarize reference water quality conditions (**table 2.II.B-11**). Sources of information and assumptions are presented below.

Table 2.II.B-11: Reference range of variability for significant factors.

Factor	Value

Trace and heavy metals - Lead	0.005 – 0.03 mg/L
Turbidity	0.32 – 23 NTU
Suspended solids	0.00 – 24.40 mg/L

Trace and heavy metals – Lead: A total of 3 samples from Mills Creek *upstream* of the Mills Creek Development Company mining claim were analyzed for trace and heavy metals in 1980 (Blanchet, 1981), and 1 sample was measured *upstream* of the Mills Creek Mine in 1994 (Ecology and Environment, 1995).

Turbidity: A total of 2 samples from Mills Creek *upstream* of the Mills Creek Development Company mining claim were analyzed for turbidity in 1980 (Blanchet, 1981). Additionally, 24 samples on Mills Creek just upstream of the confluence with Canyon Creek, and 35 samples on Canyon Creek just downstream of the confluence with Mills Creek were analyzed for turbidity (Huber and Blanchet, 1992). These sample locations are *upstream* of numerous placer mining operations on Canyon Creek, although they might be affected by mining operations further upstream on Mills Creek.

Suspended solids: A total of 2 samples from Mills Creek *upstream* of Mills Creek Development Company mining claim were analyzed for suspended solids in 1980 (Blanchet, 1981). Additionally, 24 samples on Mills Creek just upstream of its confluence with Canyon Creek, and 35 samples on Canyon Creek just downstream of Mills Creek were analyzed for suspended solids (Huber and Blanchet, 1992). These sample locations are *upstream* of numerous placer mining operations on Canyon Creek, although they might be affected by mining operations further upstream on Mills.

d. Interpretations of change

Trace and heavy metals –Lead – Measured trace and heavy metal concentrations in Mills Creek included one sample located downstream of mining that had a lead concentration slightly greater than the state water quality standard. Although these data are limited to only 4 pairs of samples, they show a possible effect of placer mining operations on lead concentrations downstream. However, the data are too limited to draw conclusions.

Turbidity– An increase in turbidity of over 26 NTU from upstream of a mining operation on Mills Creek to downstream of the mine was recorded on 8/15/1980. State standards allow for no more than a 25 NTU increase above natural levels in fish bearing streams. Although it is not a salmon stream, Mills Creek flows into Canyon Creek and Sixmile Creek, both of which provide salmon habitat.

The highest turbidities were measured in Mills Creek. Although this may be related to mining operations on Mills Creek, it may also be a function of natural turbidity levels from glacial silt as well as sediment derived from the landslide area on Juneau Creek. Turbidities on Canyon Creek just downstream of Mills Creek are slightly less than those recorded in Mills Creek just upstream of the Canyon Creek confluence, suggesting that turbidity levels diminish downstream with additional flow from tributaries. Furthermore, the lowest turbidities were measured on Canyon Creek at the confluence with East Fork Sixmile Creek, despite being located downstream of several suction dredging operations. This indicates that increases in turbidity from placer mining operations may be short-term and localized. However, these data may not reflect the results of mining operations because sampling may not have coincided with mining. An understanding of the effects of different placer mining techniques on water quality, the duration of these turbidity increases, and short-term dramatic increases in turbidity from sediment input from the Juneau Creek landslide area would further help manage water quality problems.

Suspended solids – Suspended solid concentrations follow the same trends as the turbidity levels in Mills Creek and Canyon Creek. The highest suspended solid concentration, 85.5 mg/L, was measured downstream of the placer mining operation at the Mills Creek Development Company (Blanchet, 1981). This represents an increase of over 80 mg/L from upstream of the mine to downstream of the mine. Like turbidity, data from Huber and Blanchet (1992) showed that suspended solid concentrations decreased downstream in Canyon Creek with the addition of flow from tributaries, despite the presence of placer mines. Like turbidity, increases in suspended solid concentrations are likely short-term and localized.

4. Groundwater and wetlands

Based on US Fish and Wildlife Service mapping, wetlands cover only a small portion of the Sixmile/Canyon Creek analysis area (1.2%) (**table 2.II.B-12**). The majority of the wetlands in this area are located in the narrow valley bottoms. However, numerous small, unmapped wetlands exist within the watershed along small gullies and slope drainages in both forested and alpine areas. They were not mapped during the National Wetlands Inventory conducted by the US Fish and Wildlife Service because of their small size and the difficulty in identifying them from aerial photography.

Palustrine wetlands are the most common type in this area, covering 1107 acres of the watershed, predominantly in the bottoms of the larger stream valleys. Riverine wetlands exist along lower Sixmile Creek and East Fork Sixmile Creek, and estuarine wetlands exist at the mouth of Sixmile Creek. Lacustrine wetlands include upper and lower Summit Lakes, and shallow water tables associated with alluvial fan deposits are known to exist at the northern end of Summit Lake. Wells at the Tenderfoot Campground and the Summit Lake Lodge tap into this groundwater source.

Table 2.II.B-12: Wetland types and number of acres of each type in the Sixmile Creek watershed. Data from USDA Forest Service, updated 1997.

Wetland type	Total # of acres
Palustrine	1107
Estuarine	204
Riverine	376
Lacustrine	423
TOTAL	2110

Landtype Associations

Landtype Associations are the most generalized topographic map units at the landscape level of the Ecological Hierarchy (Bailey, 1993) that have been delineated over this area (Figure 2). They are based on similar geomorphic process, soil complexes, stream types, geology, and plant communities in repeatable patterns. They provide a simple method to delineate the landscape and provide guidance as to limitations for the implementation of management activities or projects. The table in Figure 1 shows the LTA's and the area they represent in the assessment area.

Landtype Association (Map Unit)	Acreage
Mountain Summits (10)	81,100
Mountain Sideslopes (30)	61,800
Depositional Slopes (40)	3,300
Moraines (60)	2.200
Outwash (80)	12,900
Hills (90)	14,400
Clear Water (CW)	400

Figure 1. Landtype Associations and the acreage of each found in the Canyon Creek/Six Mile Landscape Assessment.

A short description of the characteristics and processes defining the associations are found below.

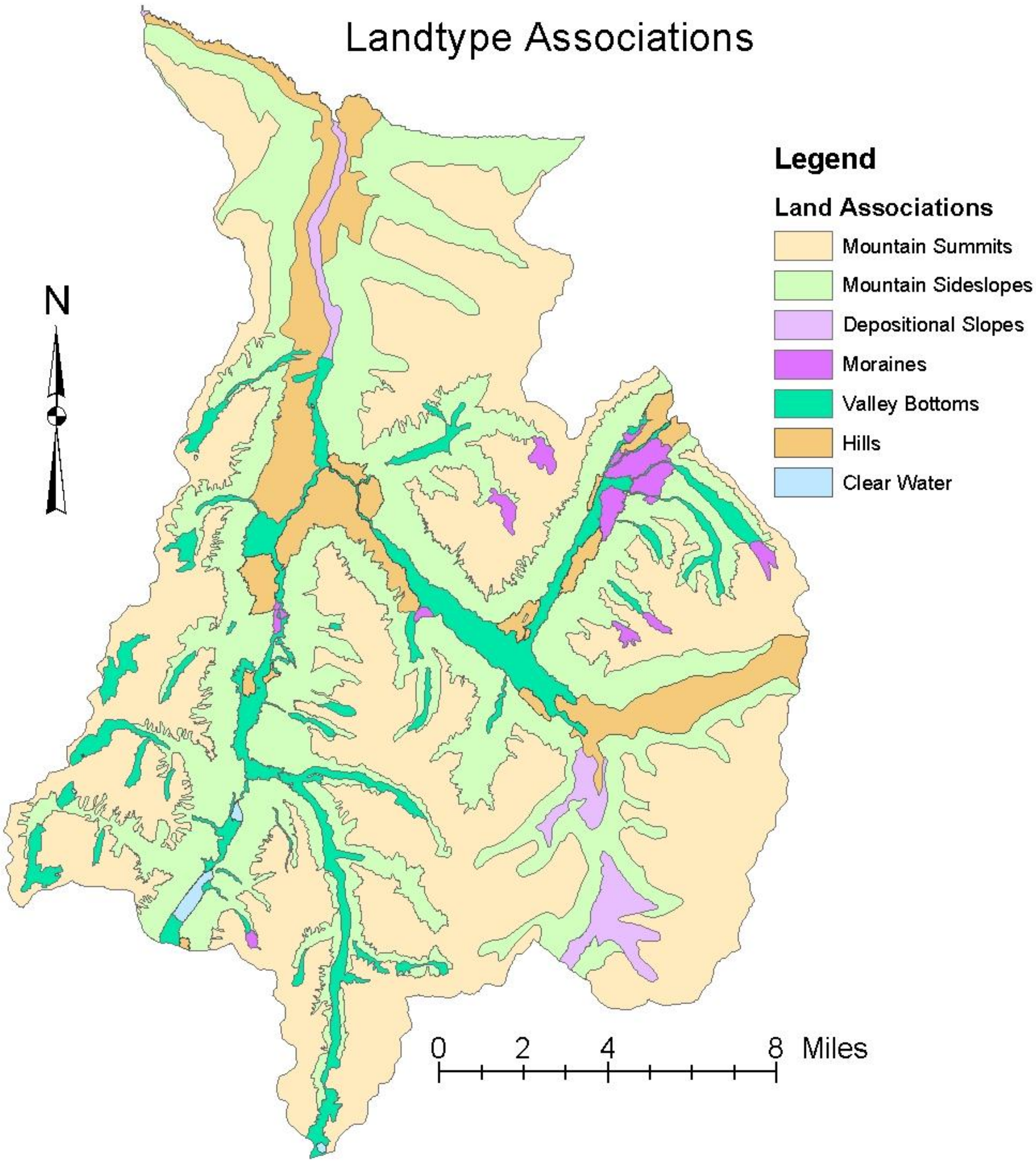


Figure 2. Landtype Associations of the Canyon Creek/Six Mile Assessment Area

Mountain Summits

This association includes the ridges, peaks, cirque headwalls and basins and the associated scree slopes. Glaciation has been the most dominant historical geomorphic force that shaped the landscape. Frost fracturing has resulted in some cases rounded mountaintops and ridges cover by a layer of loose rock. Most of the water runs off the surface where bedrock is exposed or beneath the surface where significant depths of loose rock have accumulated. The vegetation is mostly low growing forbs, grasses, and lichens where there is sufficient soil, and some willows and other woody plants in localized wet areas.

Mountain Sideslopes

This association includes sideslopes, glaciated or non-glaciated, smooth or irregular, that normally receive surface or subsurface water draining from alpine landscapes. Slope steepness normally ranges from 15 to 70 percent. The most dominant process shaping the steeper slopes in this category is erosion and transportation of sediment downslope due to gravity. Erosion from surface water usually results in a parallel drainage pattern with V-notched channels of variable depths and densities. Other soil and rock that is loosened by frost and water rolls down the slopes or is carried down by avalanches. This material is deposited on the lower, less steep slopes. The soils are normally medium textured, well drained, and moderately to well developed. Some of these soils on the lower slopes consist of compact glacial till which is more poorly drained and less productive for forests than other soils in the association. The upper sideslopes are commonly vegetated with low growing subalpine plants which grade into mixed communities of grasses, shrubs, and trees on the lower slopes. The location of trees is strongly dependent on disturbance by avalanches.

Coastal

This association includes landscapes that are the result of marine processes such as tidal fluctuations, wave carving and splash, and blowing sand. Examples include estuaries, beaches, marine deltas, and marine terraces. Most often these sites have slopes less than 15 percent. The soil may consist of either poorly drained silts deposited in low energy environments or well-drained sands deposited in high energy environments. Some of the landscapes have been uplifted by isostatic rebound after glacial recession or from earthquakes. Uplifted landscapes are no longer associated with the active processes of the ocean and may be located inland from the ocean. The vegetation found on these landforms depends on how long the site has been separated from active wave processes, and the drainage of the soil. Old uplifted beaches have some of the most productive forested sites on the forest. The poorly drained soils on deltas or tidal flats, and marine terraces produce the largest expanses of wetlands.

Outwash
This association includes all landscapes that are a result of fluvial deposition of sediment as a result of upland erosion. Much of this association is exposed to occasional or frequent flooding depending on the proximity to rivers. Examples are alluvial plains, glacial outwash plains, braided glacial rivers and the included islands or sand bars, low relief river terraces, and narrow valley bottoms that contain a combination of the above landscapes. This association also includes large sand dunes. The soils include both poorly drained lacustrine silts and clays, and well-drained alluvial loams, sands, and gravels. The vegetation on the poorly drained, fine textured soils will be indicative of wetlands where the surface is level, and a poorly productive forest on gentle slopes. The coarse textured soils will produce highly productive forests.

Hills
This association includes hills and plateaus that do not receive surface or subsurface water flow from adjacent uplands. This excludes major rivers or creeks that may flow through the hills that originate from other areas. The surface character of these landscapes is often controlled by the stratigraphy of the bedrock. A veneer of glacial till frequently covers these landscapes. The soils are normally well-drained, medium to coarse texture on the sideslopes, and poorly drained fine to medium textured and shallow in the basins or low areas between the hills. The vegetation will usually consist of forested communities on the slopes and hilltops where the soils are well drained. The vegetation in the small basins or valleys in-between the hills will commonly be associated with wet soils or wetlands.

Landtypes

The lower portions of the accessible valleys are delineated at the Landtype level, which is one level of greater detail than the Landtype Associations. These units delineate a unit of land that is defined by one major hydrologic/geomorphic process, and a maximum of three major soils and associated plant communities. This level of landscape delineation is intended for project design and implementation. Most frequently the landtype level map units are a more detailed delineation of a mother landtype association (Ex. Mountain Sideslopes Landtype Association includes Mountain Sideslopes – Non-disturbed, Disturbed, Broken, Dissected, etc.).

The original version of the landtypes for the Kenai Peninsula are found in the Soil Resource Inventory of the Kenai Peninsula (Davis, 1980). There is not a written report that describes the complete characteristics of the updated landtypes updated since this publication, but a map of the landtypes and the field delineation criteria for each is found in the Appendix A. The descriptions for the landtypes are located in the NRIS Terra electronic database, and the maps showing their location is located in the Forest GIS database. The landtypes are further delineated into Landtype Phases, which are defined by one geomorphic process, one major soil, and one major plant community. The portion of the assessment that are mapped at the landtype phase level include the East Fork or Six Mile Creek and Canyon Creek valleys. The vegetation data for landtype phases is located in the GIS, and the soils and landform data is located on paper field sheets.

There is a soil survey (Davidson, 1989) that provides the most detail data and mapping for the soils and their interpretations for the road corridor on the Kenai Peninsula. The mapped area includes all road accessible valleys on the forest and the mapped area extends upslope to the highest extent of the trees.

C. Landslide Risk

Areas that frequent or have the potential for landslides usually present an unnecessary risk for most soil disturbing types of management activities. Landslides most frequently

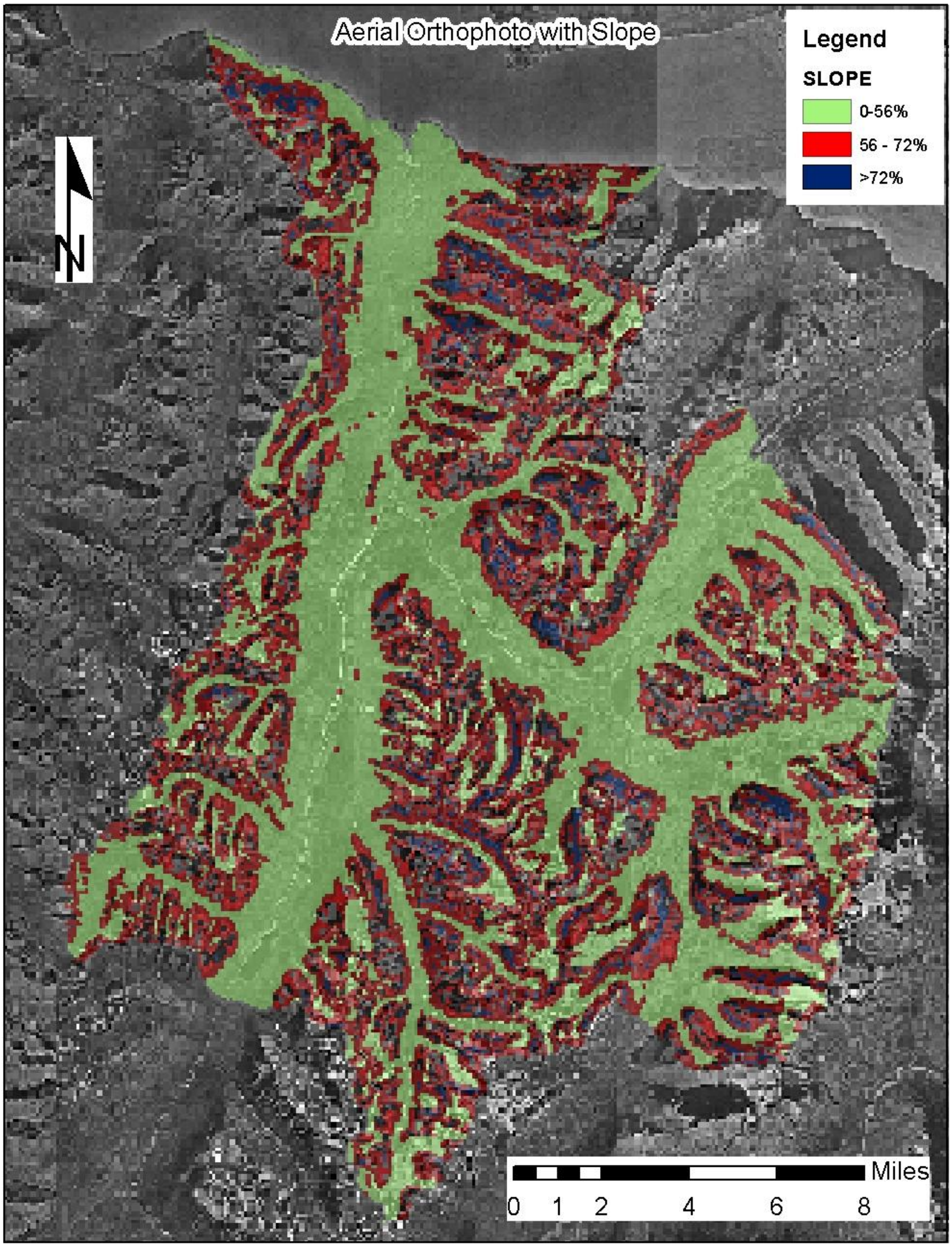


Figure 5. Slope categories in the Assessment Area

occur on slopes greater 72 percent (Swanston, 1997). That isn't to exclude slopes with gradients less that 72 percent if the correct soil and hydrologic conditions are present.

The most critical factor used in the risk assessment is the steepness of the slope. Figure 5 shows an aerial photo mosaic with delineations of slope gradients that are less that 56 percent, 56 to 72 percent, and greater than 72 percent. Figure 6 shows the Landtype Associations overlaid with the slope categories.

A preliminary analysis for the potential occurrence of a landslides was done for the LTA's with sideslopes. The method used was developed by Douglas N. Swanston (1997) for the Tongass Land Management Plan. This system uses data easily collectable in the field that includes soil properties such as soil texture, parent material, depth, drainage; and specific topographic conditions such as slope shape, length, gradient and drainage density. The risk assessment weights each of the characteristics as to their relative importance, and then provides a numerical landslide failure rating. A higher rating indicates a higher the risk for a landslide. Sites with a risk rating above 63 are considered to have a relatively "high risk" for landslides. Any soil disturbance will increase the risk. A preliminary analysis (Appendix B) was completed for the representative soils and conditions on the Mountain Sideslopes LTA and Ravines LT.

The landtype associations inventory documents that the majority of the slopes over 56 percent are located in the Mountain Sideslopes and the Alpine LTA's with a minor amount in the Depositional LTA (Figure 6). Most of the soils in these LTA's have a loamy skeletal texture and are well drained, which places them in the low to moderate landslide risk category. There is usually a large alpine area, in the Mountain Summits LTA, above the Mountain Sideslopes LTA that collects ground water that runs down the sideslopes. Many sideslopes in South-central Alaska have also been shaped by glaciers and in the process left a water restricting layer of compact till on the sideslopes. The compact till appears to be necessary to perch the additional water that increases the risk for landslides. This layer appears to be relatively uncommon in the assessment area, hence no landslides have been documented to date.

The Ravines Landtype, which commonly occurs in the Depositional LTA, consists of steep river-cut sideslopes resulting from rivers cutting down thru bedrock and well-drained fluvial sediments. This is verified along Cooper Creek where the creek has undercut an already over-steepened cut slope which has resulted in reoccurring landslides. Where the soils are wet, have poorer drainage or contain fine texture lacustrine deposits, there is a high risk for a landslide. This is verified in the lower portion of Resurrection Creek where numerous landslides have been documented in lacustrine soils on steep river-cut slopes. Although these more poorly drained soils have not been specifically mapped in the assessment area, they are easily identified by water loving vegetation.

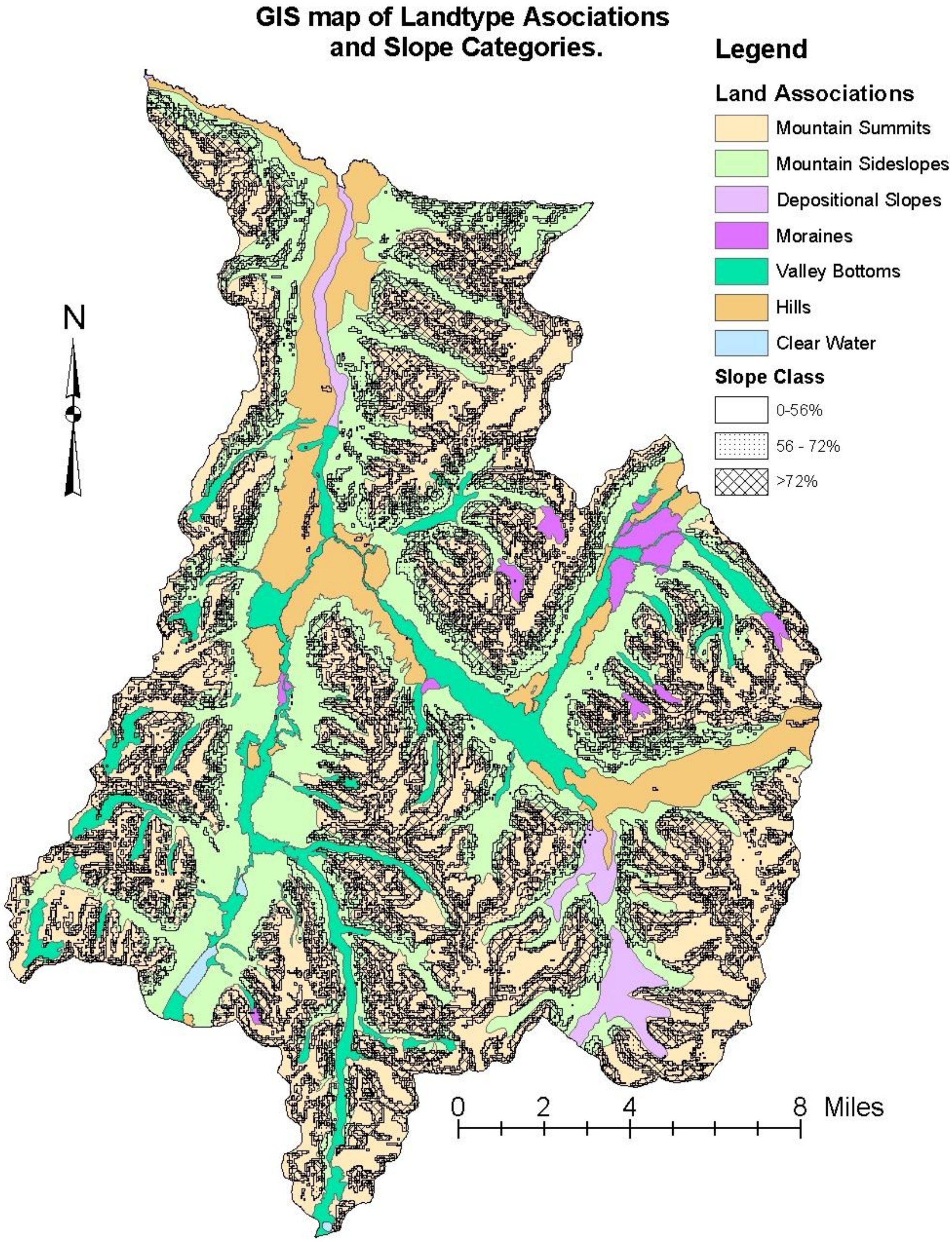


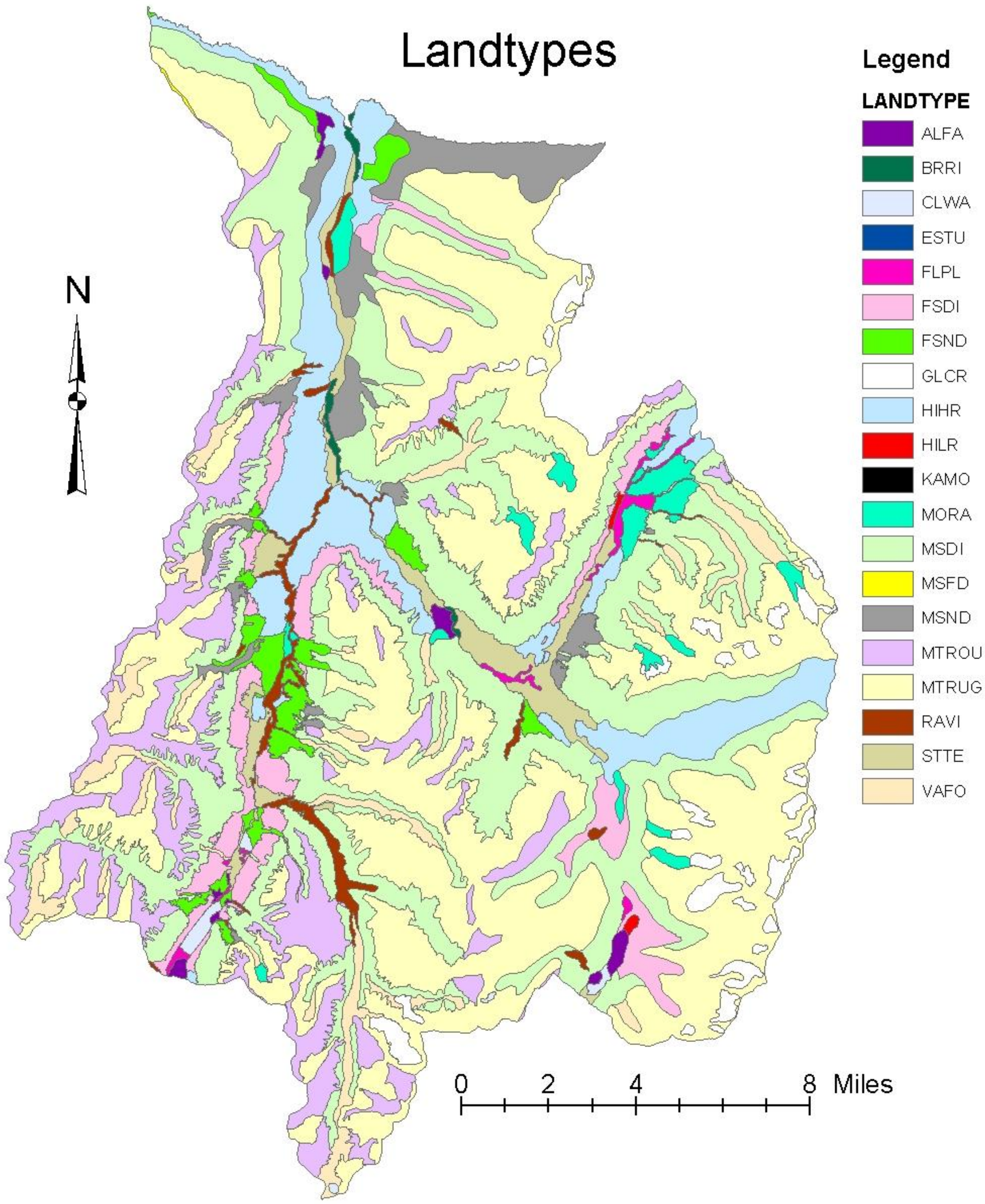
Figure 6. Slope categories and locations in the Landtype Associations

	Acreage for each Slope Category		
Landtype Association	**Slopes <56%**	**56 to 72%**	**Slopes 72%<**
Mountain Summits (10)	39,600	21,700	19,700
Mountain Sideslopes (30)	41,400	14,600	5,800
Depositional Slopes (40)	3,300	40	0
Moraines (60)	2,200	20	0
Outwash (80)	12,600	200	60
Hills (90)	14,200	100	20

Figure 7. The land area that occurs in each of three slope categories for each Landtype Association.

Appendix A.

Field Delineation Criteria for Landtypes on the Kenai Peninsula



Landtypes of the Canyon Creek/Six Mile Landscape Assessment Area

MTRUG Rugged Mountain Summits

General Picture: Includes the jagged rocky ridges, peaks, associated scree slopes, cirque basins, and headwalls.Glaciation has been the most dominant historic geomorphic force which shaped the landscape. Frost has continued to fracture rock causing continuous rock fall.

Field Clues:
1. Usually jagged, rocky summits and ridges
2. Internal relief is usually greater than 100 feet
3. Dominant slope gradient is greater than 65 percent
4. Exposed bedrock and unvegetated talus comprise greater than 50 percent
5. Includes terrain down to the upper shoulder slopes of lower landscapes.

Hydrology: Snowmelt and rainfall produce mainly surfical runoff that collects in streams for transport to landscapes at lower elevations.

MRTOU - Rounded Mountain Summits

General Picture: Rounded ridges and summits and the associated shoulderslopes which have not been glaciated, but are more the result of present cryoplanation.

Field Clues:
1. Rounded non-glaciated alpine mountain summits and ridges
2. The major landscape forming process is frost wedging
3. Internal relief is generally less than 100 feet
4. Slope gradient is usually less than 65 percent
5. Slopes are usually convex

Hydrology: Snowmelt and rainfall produce mainly subsurface runoff due to the intensive fracturing of the surface rock. Surface runoff will sometimes occur during major rain storms.

GLCR - Glaciers

General Picture: Large glaciers and ice fields and the included rocky mountain peaks and ridges.

Field Clues: Continous glaciers and rock peaks with little or no vegetation.

Hydrology: Snow and ice melt provide water to lower outwash landscapes.

SUROU - Subalpine Hilltops and Ridges

General Picture: Those mostly rounded ridges, hill tops, and plateaus that have shrub, graminoid, and herbaceous vegetation that is very characteristic of subalpine conditions.

Field Clues:
1. Mid elevation broad ridges, ridge summits, and hill tops
2. Does not include perennial snow fields or glaciers
3. Internal relief is less than 100 feet.
4. Overall slope gradient is less than 45 percent.

30 – Mountain Sideslopes Landtype Association

General Picture: Includes the higher relief mountain sideslope landscapes that are commonly located immediately below the alpine landscapes where erosion, transportation, and deposition of sideslope soil and rock material are the dominant processes.

Field Clues:
1. External relief is usually greater than 1,000 feet.
2. Dissecting stream usually originate in Alpine LTA and develop a parallel pattern unless they are interrupted by benches.
3. A major portion of the slope hydrology on these landtypes is a continuatioin of water contributed from alpine landscapes at higher elevations.

MSND – Mountain Sideslopes – Non-disturbed

General Picture: Mostly tree covered sideslopes a result of the relatively favorable climate at lower elevations, unactive slopes, and low avalanche and drainage channel density.

Field Clues:
1. External relief is usually greater than 1,000 feet.
2. Greater than 40 percent of the map unit has trees that are periodically separated by active avalanche and scree slopes.
3. The drainage pattern is usually parallel unless it is interrupted by benches, etc.
4. Dissections or drainage channels make up less than 40 percent of the map unit.
5. Dominant slope gradient is usually greater than 35 percent.

MSDI - Mountain Sideslopes - Disturbed

General Picture: Mostly shrub, graminoid, and herbaceous covered sideslopes as a result of a somewhat unfavorable climate at low to moderate elevations, somewhat active slopes, and a low to moderate density of avalanche occurrences and drainage channels.

Field Clues:
1. External relief is usually greater than 1,000 feet.
2. Less than 40 percent of the map unit is covered by trees.
3. The drainage pattern is usually parallel unless it is interrupted by benches, etc.
4. Dissections or drainage channels make up less than 40 percent of the map unit.

FSND – Footslopes - Non-Disturbed

General Picture: The mostly tree covered lower, concave portion of glaciated sideslopes that is the result of glacial carving and the depostion of coluvium from the above sideslopes.

Field Clues:
1. Located in footslope positions
2. Average slope gradient is less than 35 percent
3. Greater than 40 percent of the map unit is vegetated by trees.
4. The soil parent material usually consists of colluvial, alluvial, or glacial till most of which eroded from soil upslope.

FSDI – Footslopes - Disturbed

General Picture: The mostly shrub, graminoid, or herbaceous covered lower, concave portions of lower glaciated sideslopes that are the result of glacial carving and the depostion of coluvium and avalanche debris from the above sideslopes. Elevation and climate commonly influence the plant species.

Field Clues:
1. Located in footslope positions
2. Average slope gradient is less than 35 percent
3. Less than 40 percent of the map unit is vegetated by trees.
4. The soil parent material usually consists of colluvial, alluvial, or glacial till most of which eroded from soil upslope.

MSFD – Mountain Sideslopes – Frequently Dissected

General Picture: Tree or shrub covered, densely dissected sideslopes which are the result of intensive water erosion or strong frost action on easiy weathered or highly fracture bedrock.

Field Clues:
1. Slope gradient is usually greater than 65 percent.
2. Slope length is usually greater than 1000 feet.
3. An intensive dendritic or parallel drainage pattern.
4. Dissections or drainage channels make up greater than 40 percent of the map unit.
5. Commonly found on a marine sedimentary mudstone or siltstone bedrock.

60-Moraines Landtype Association

General Picture: Includes level and gently undulating terrain at lower elevations that have been shaped by glacial or marine forces.

1. Average slope gradient is from 0 to 35 percent.
2. Relief is less than 50 feet between hills and depressions.
3. In undulating topography the hills and knobs make up the minor component.

MORA – Kame Moraines

General Picture: A mozaic of small hills, basins, and ablation deposits of glacial moraine origin that may be covered by any vegetation depending on elevation and time since depostion.

Field Clues:
1. Topography is undulating, being composed of numerous knobs and depressions
2. Slope gradient usually ranges from 5 to 35 percent
3. Relief usually is less than 100 feet between knobs and depressions
4. Located on till plains and outwash plains

MORA – Moraines (Undifferentiated)

General Picture: Terminal, lateral, and medial moraines left by glacial recession. Commonly vegetated by any plant species depending on the elevation and time since deposition.

1. Terminal, lateral, and medial moraines

2. External relief is usually less than 200 feet.
3. Slope gradient ranges from 35 to 65 percent.
4. Usually restricted to lowlands or the lower portion of glacial valleys.

70-Coastal Landtype Association

General Picture: Includes those landscapes that are adjacent to salt water and are formed from either depostion of sediment by the ocean or wind. Landscapes that have been tectonically uplifted and subsequently leveled by wave action.

1. One major border of the map units is the seawater.
2. These map units have or are presently being shaped by the sea water.

ESTU - Estuary

General Picture: Mostly level marine landscapes, either nonvegetated or covered by emergent plant species, that consist of fine grain marine sediments which are normally inundated daily by ocean tides.

1. Contains the mouth of streams as they enter the sea water.
2. Inundated by saltwater during tidal fluctuations.
3. Contains relief of less than 15 feet.
4. Slope is less than 5 percent.
5. Exposed at mean low tide.

80 (GO) - Depositional Landtype Association (50)

1. Restricted to valley bottoms or open plains covered by loose surfical deposits resulting from glacial, fluvial, or coluvial processes.
2. Average slope gradient is less than 35 percent.
3. Not inundated by saltwater during tidal fluctuations.

ALFA - Alluvial Fans

1. Composed of deep surfical alluvial deposits located at the mouth of a sidevalley or tributary stream channel.
2. Average slope gradient is usually less than 25 percent.
3. External relief is usually less than 100 vertical feet.
4. Stream channels are usually somewhat unstable.

FLPL - Flood Plain

1. Develop in and below clear water nonglacial streams NOT associated with active glaciers.
2. Flooding is usually the result of spring snow melt runoff or large rain storms
3. Usually has a slope gradient less than 5 percent.
4. Stream pattern is usually meandering or braided.
5. Dominated by deep alluvial deposits

OUPL - Outwash Plain

1. Develops below and is the result of glacial runoff
2. Flooding is usually dominated by high melt-water runoff from glaciers and rain storms
3. Usually has a slope gradient less than 5 percent
4. Rivers are agrading and usually have a meandering or braided pattern
5. Dominated by deep alluvial deposits

RAVA - Ravines

1. Restricted to Mountain or hill slopes.
2. Slope gradient is usually greater than 65 percent.
3. External and internal relief is usually between 50 and 200 feet.
4. Sideslopes are usually dominated by V-notches of varying depths.

VAFL - Valley Floor

1. Normally found in narrow to moderately wide valley bottoms and have a typically small and very narrow flood plain
2. Landforms are the result of alluvial processes
3. Most slope gradients range from 0 to 35 percent
4. Internal and external relief is usually less than 50 vertical feet and normally between 10 and 35 feet.

STTE - Stream Terrace

1. Restricted to valley bottoms
2. Consists of deep alluvial deposits that are no longer exposed to floods.
3. Flat or gently undulating surface where the slope gradient is usually less than 5 percent.
4. Usually adjacent to a steep cut slope (gradient greater than 65 percent) where the original drainage channel has cut down through much of the deposits.

5. External relief is usually greater than 15 feet.

90 - Hills Landtype Association

1. Comprises or gently rolling lowlands one or more distinctly separate hills.
2. Slopes are less than 1000 feet in length.
3. The slope hydrology originates within these landtypes and there is no contribution from other landtypes at higher elevations except where major rivers or creeks run through continuing valleys.

HILR – Hills – Low Relief

1. Slope gradient is usually greater than 35 percent
2. External relief ranges from 50 to 200 feet.
3. Greater than 60 percent of the map unit is covered by hilly peatland.
4. Usually occur from 0 to 1500 feet in elevation.
5. Landscape may be dissected by gorges 50 to 200 feet deep cut into bedrock.

HIHR – Hills – High Relief

1. Slope gradient is usually greater than 35 percent.
2. External relief ranges from 200 to 1000 feet.
3. Greater than 60 percent of the map unit is covered by tree covered sideslopes.
4. Usually occur from 0 to 1500 feet in elevation.
5. Landscape is commonly dissected by gorges 50 to 200 feet deep cut into the bedrock.

Appendix B

Landslide Risk Assessment Calculation Sheets

Site: MSDI LTA (30)	Subalpine veg. Convex upper nonforested shoulder slope						

Criteria	1	2	3	4	Criteria Value	Weighting Factor	Rating
Landform							
Slope shape	Vertical	Broken	Convex	Concave-straight	3	5	15
Slope lenght (ft)	0-300	301-700	701-1500	>1500	2	5	10
Slope gradient (%)	May-35	36-55	56-72	>72	3	20	60
Drainage features:							0
Drainage density (% of area)	9-Jan	10-129	20-39	>40	1	10	10
Soils							0
Soil drainage class	WD	MWD	SPD	VP,PD	1	10	10
Soil Depth (in)	>40		20-40	<20	1	5	5
Geology							0
Parent material	Carbonate, colluvium, alluvium	Noncarbonate, granitics, glacial till	Compact till, marine sediments	Volcanic ash	1	5	5
Textural class	Sand, gravel, fragmental loam	loam	silt	silty clay	2	5	10
total of Ratings							125
Failure Hazard Rating							0.4808

*>63,High: 62-50,Moderate; 28-49,low: <28, None; Moderate risk

Site: MSDI Frequently dissected, Upper non-forested sideslope, Somewhat Poorly Drained soil
LTA (30)

Criteria	1	2	3	4	Criteria Value	Weighting Factor	Rating
Landform							
Slope shape	Vertical	Broken	Convex	Concave-straight	4	5	20
Slope lenght (ft)	0-300	301-700	701-1500	>1500	3	5	15
Slope gradient (%)	May-35	36-55	56-72	>72	4	20	80
Drainage features:							0
Drainage density (% of area)	9-Jan	10-129	20-39	>40	2	10	20
Soils							0
Soil drainage class	WD	MWD	SPD	VP,PD	3	10	30
Soil Depth (in)	>40		20-40	<20	1	5	5
Geology							0
Parent material	Carbonate, colluvium, alluvium	Noncarbonate, granitics, glacial till	Compact till, marine sediments	Volcanic ash	1	5	5
Textural class	Sand, gravel, fragmental loam	loam	silt	silty clay	1	5	5
total of Ratings							180
Failure Hazard Rating							0.6923

*>63,High: 62-50,Moderate; 28-49,low: <28, None; High Risk

Site: MSDI LTA (30)	Smooth forested sideslope, Well Drained soil						
Criteria	**1**	**2**	**3**	**4**	**Criteria Value**	**Weighting Factor**	**Rating**
Landform							
Slope shape	Vertical	Broken	Convex	Concave-straight	5	5	25
Slope lenght (ft)	0-300	301-700	701-1500	>1500	3	5	15
Slope gradient (%)	May-35	36-55	56-72	>72	3	20	60
Drainage features:							0
Drainage density (% of area)	9-Jan	10-129	20-39	>40	1	10	10
Soils							0
Soil drainage class	WD	MWD	SPD	VP,PD	1	10	10
Soil Depth (in)	>40		20-40	<20	1	5	5
Geology							0
Parent material	Carbonate, colluvium, alluvium	Noncarbonate, granitics, glacial till	Compact till, marine sediments	Volcanic ash	1	5	5
Textural class	Sand, gravel, fragmental loam	loam	silt	silty clay	2	5	10
total of Ratings							140
Failure Hazard Rating							0.5385

*>63,High: 62-50,Moderate; 28-49,low: <28, None;

Site: RAVI Typic Cryaquents, lsk.m Poorly Drained Soils
LTA (40)

Criteria	1	2	3	4	Criteria Value	Weighting Factor	Rating
Landform							
Slope shape	Vertical	Broken	Convex	Concave-straight	4	5	20
Slope lenght (ft)	0-300	301-700	701-1500	>1500	1	5	5
Slope gradient (%)	May-35	36-55	56-72	>72	4	20	80
Drainage features:							0
Drainage density (% of area)	9-Jan	10-129	20-39	>40	1	10	10
Soils							0
Soil drainage class	WD	MWD	SPD	VP,PD	4	10	40
Soil Depth (in)	>40		20-40	<20	1	5	5
Geology							0
Parent material	Carbonate, colluvium, alluvium	Noncarbonate, granitics, glacial till	Compact till, marine sediments	Volcanic ash	3	5	15
Textural class	Sand, gravel, fragmental loam	loam	silt	silty clay	2	5	10
total of Ratings							185
Failure Hazard Rating							0.7115

*>63,High: 62-50,Moderate; 28-49,low: <28, None; High Risk

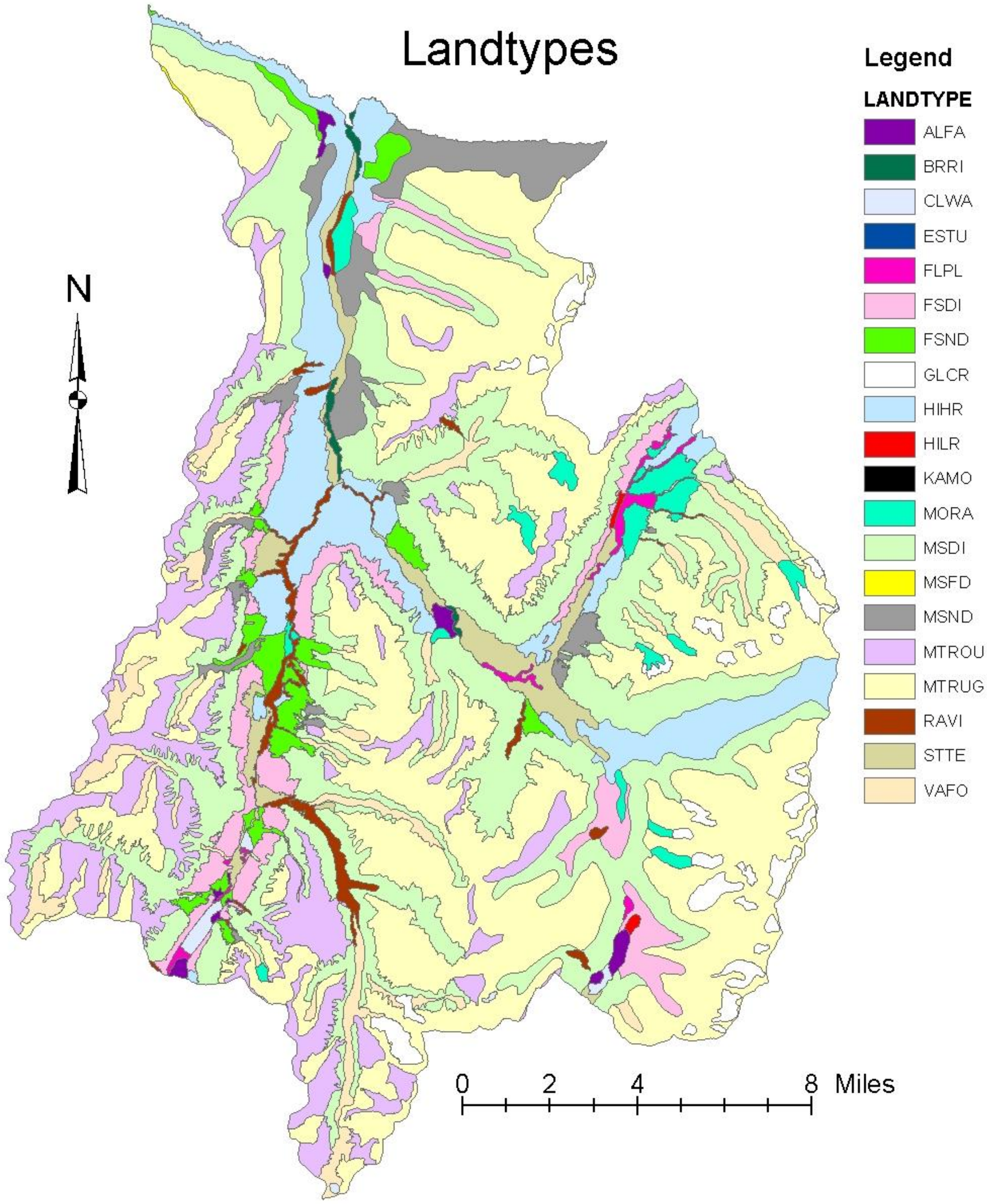
Site: RAVI, Typic Haplocryods, lsk, m;
Well Drained soil
LTA (40)

Criteria	1	2	3	4	Criteria Value	Weighting Factor	Rating
Landform							
Slope shape	Vertical	Broken	Convex	Concave-straight	4	5	20
Slope lenght (ft)	0-300	301-700	701-1500	>1500	1	5	5
Slope gradient (%)	May-35	36-55	56-72	>72	4	20	80
Drainage features:							0
Drainage density (% of area)	9-Jan	10-129	20-39	>40	1	10	10
Soils							0
Soil drainage class	WD	MWD	SPD	VP,PD	1	10	10
Soil Depth (in)	>40		20-40	<20	1	5	5
Geology							0
Parent material	Carbonate, colluvium, alluvium	Noncarbonate, granitics, glacial till	Compact till, marine sediments	Volcanic ash	1	5	5
Textural class	Sand, gravel, fragmental loam	loam	silt	silty clay	2	5	10
total of Ratings							145
Failure Hazard Rating							0.5577

*>63,High: 62-50,Moderate; 28-49,low: <28, None; Moderate Risk

Appendix A.

Field Delineation Criteria for Landtypes on the Kenai Peninsula



Landtypes of the Canyon Creek/Six Mile Landscape Assessment Area

MTRUG Rugged Mountain Summits

General Picture: Includes the jagged rocky ridges, peaks, associated scree slopes, cirque basins, and headwalls.Glaciation has been the most dominant historic geomorphic force which shaped the landscape. Frost has continued to fracture rock causing continuous rock fall.

Field Clues:
1. Usually jagged, rocky summits and ridges
2. Internal relief is usually greater than 100 feet
3. Dominant slope gradient is greater than 65 percent
4. Exposed bedrock and unvegetated talus comprise greater than 50 percent
5. Includes terrain down to the upper shoulder slopes of lower landscapes.

Hydrology: Snowmelt and rainfall produce mainly surfical runoff that collects in streams for transport to landscapes at lower elevations.

MRTOU - Rounded Mountain Summits

General Picture: Rounded ridges and summits and the associated shoulderslopes which have not been glaciated, but are more the result of present cryoplanation.

Field Clues:
1. Rounded non-glaciated alpine mountain summits and ridges
2. The major landscape forming process is frost wedging
3. Internal relief is generally less than 100 feet
4. Slope gradient is usually less than 65 percent
5. Slopes are usually convex

Hydrology: Snowmelt and rainfall produce mainly subsurface runoff due to the intensive fracturing of the surface rock. Surface runoff will sometimes occur during major rain storms.

GLCR - Glaciers

General Picture: Large glaciers and ice fields and the included rocky mountain peaks and ridges.

Field Clues: Continous glaciers and rock peaks with little or no vegetation.

Hydrology: Snow and ice melt provide water to lower outwash landscapes.

SUROU - Subalpine Hilltops and Ridges

General Picture: Those mostly rounded ridges, hill tops, and plateaus that have shrub, graminoid, and herbaceous vegetation that is very characteristic of subalpine conditions.

Field Clues:
1. Mid elevation broad ridges, ridge summits, and hill tops
2. Does not include perennial snow fields or glaciers
3. Internal relief is less than 100 feet.
4. Overall slope gradient is less than 45 percent.

30 – Mountain Sideslopes Landtype Association

General Picture: Includes the higher relief mountain sideslope landscapes that are commonly located immediately below the alpine landscapes where erosion, transportation, and deposition of sideslope soil and rock material are the dominant processes.

Field Clues:
1. External relief is usually greater than 1,000 feet.
2. Dissecting stream usually originate in Alpine LTA and develop a parallel pattern unless they are interrupted by benches.
3. A major portion of the slope hydrology on these landtypes is a continuatioin of water contributed from alpine landscapes at higher elevations.

MSND – Mountain Sideslopes – Non-disturbed

General Picture: Mostly tree covered sideslopes a result of the relatively favorable climate at lower elevations, unactive slopes, and low avalanche and drainage channel density.

Field Clues:
1. External relief is usually greater than 1,000 feet.
2. Greater than 40 percent of the map unit has trees that are periodically separated by active avalanche and scree slopes.
3. The drainage pattern is usually parallel unless it is interrupted by benches, etc.
4. Dissections or drainage channels make up less than 40 percent of the map unit.
5. Dominant slope gradient is usually greater than 35 percent.

MSDI - Mountain Sideslopes - Disturbed

General Picture: Mostly shrub, graminoid, and herbaceous covered sideslopes as a result of a somewhat unfavorable climate at low to moderate elevations, somewhat active slopes, and a low to moderate density of avalanche occurrences and drainage channels.

Field Clues:
1. External relief is usually greater than 1,000 feet.
2. Less than 40 percent of the map unit is covered by trees.
3. The drainage pattern is usually parallel unless it is interrupted by benches, etc.
4. Dissections or drainage channels make up less than 40 percent of the map unit.

FSND – Footslopes - Non-Disturbed

General Picture: The mostly tree covered lower, concave portion of glaciated sideslopes that is the result of glacial carving and the depostion of coluvium from the above sideslopes.

Field Clues:
1. Located in footslope positions
2. Average slope gradient is less than 35 percent
3. Greater than 40 percent of the map unit is vegetated by trees.
4. The soil parent material usually consists of colluvial, alluvial, or glacial till most of which eroded from soil upslope.

FSDI – Footslopes - Disturbed

General Picture: The mostly shrub, graminoid, or herbaceous covered lower, concave portions of lower glaciated sideslopes that are the result of glacial carving and the depostion of coluvium and avalanche debris from the above sideslopes. Elevation and climate commonly influence the plant species.

Field Clues:
1. Located in footslope positions
2. Average slope gradient is less than 35 percent
3. Less than 40 percent of the map unit is vegetated by trees.
4. The soil parent material usually consists of colluvial, alluvial, or glacial till most of which eroded from soil upslope.

MSFD – Mountain Sideslopes – Frequently Dissected

General Picture: Tree or shrub covered, densely dissected sideslopes which are the result of intensive water erosion or strong frost action on easiy weathered or highly fracture bedrock.

Field Clues:
1. Slope gradient is usually greater than 65 percent.
2. Slope length is usually greater than 1000 feet.
3. An intensive dendritic or parallel drainage pattern.
4. Dissections or drainage channels make up greater than 40 percent of the map unit.
5. Commonly found on a marine sedimentary mudstone or siltstone bedrock.

60-Moraines Landtype Association

General Picture: Includes level and gently undulating terrain at lower elevations that have been shaped by glacial or marine forces.

1. Average slope gradient is from 0 to 35 percent.
2. Relief is less than 50 feet between hills and depressions.
3. In undulating topography the hills and knobs make up the minor component.

MORA – Kame Moraines

General Picture: A mozaic of small hills, basins, and ablation deposits of glacial moraine origin that may be covered by any vegetation depending on elevation and time since depostion.

Field Clues:
1. Topography is undulating, being composed of numerous knobs and depressions
2. Slope gradient usually ranges from 5 to 35 percent
3. Relief usually is less than 100 feet between knobs and depressions
4. Located on till plains and outwash plains

MORA – Moraines (Undifferentiated)

General Picture: Terminal, lateral, and medial moraines left by glacial recession. Commonly vegetated by any plant species depending on the elevation and time since deposition.

1. Terminal, lateral, and medial moraines
2. External relief is usually less than 200 feet.

3. Slope gradient ranges from 35 to 65 percent.
4. Usually restricted to lowlands or the lower portion of glacial valleys.

70-Coastal Landtype Association

General Picture: Includes those landscapes that are adjacent to salt water and are formed from either depostion of sediment by the ocean or wind. Landscapes that have been tectonically uplifted and subsequently leveled by wave action.

1. One major border of the map units is the seawater.
2. These map units have or are presently being shaped by the sea water.

ESTU - Estuary

General Picture: Mostly level marine landscapes, either nonvegetated or covered by emergent plant species, that consist of fine grain marine sediments which are normally inundated daily by ocean tides.

1. Contains the mouth of streams as they enter the sea water.
2. Inundated by saltwater during tidal fluctuations.
3. Contains relief of less than 15 feet.
4. Slope is less than 5 percent.
5. Exposed at mean low tide.

80 (GO) - Depositional Landtype Association (50)

1. Restricted to valley bottoms or open plains covered by loose surfical deposits resulting from glacial, fluvial, or coluvial processes.
2. Average slope gradient is less than 35 percent.
3. Not inundated by saltwater during tidal fluctuations.

ALFA - Alluvial Fans

1. Composed of deep surfical alluvial deposits located at the mouth of a sidevalley or tributary stream channel.
2. Average slope gradient is usually less than 25 percent.
3. External relief is usually less than 100 vertical feet.
4. Stream channels are usually somewhat unstable.

FLPL - Flood Plain

1. Develop in and below clear water nonglacial streams NOT associated with active glaciers.
2. Flooding is usually the result of spring snow melt runoff or large rain storms
3. Usually has a slope gradient less than 5 percent.
4. Stream pattern is usually meandering or braided.
5. Dominated by deep alluvial deposits

OUPL - Outwash Plain

1. Develops below and is the result of glacial runoff
2. Flooding is usually dominated by high melt-water runoff from glaciers and rain storms
3. Usually has a slope gradient less than 5 percent
4. Rivers are agrading and usually have a meandering or braided pattern
5. Dominated by deep alluvial deposits

RAVA - Ravines

1. Restricted to Mountain or hill slopes.
2. Slope gradient is usually greater than 65 percent.
3. External and internal relief is usually between 50 and 200 feet.
4. Sideslopes are usually dominated by V-notches of varying depths.

VAFL - Valley Floor

1. Normally found in narrow to moderately wide valley bottoms and have a typically small and very narrow flood plain
2. Landforms are the result of alluvial processes
3. Most slope gradients range from 0 to 35 percent
4. Internal and external relief is usually less than 50 vertical feet and normally between 10 and 35 feet.

STTE - Stream Terrace

1. Restricted to valley bottoms
2. Consists of deep alluvial deposits that are no longer exposed to floods.
3. Flat or gently undulating surface where the slope gradient is usually less than 5 percent.
4. Usually adjacent to a steep cut slope (gradient greater than 65 percent) where the original drainage channel has cut down through much of the deposits.
5. External relief is usually greater than 15 feet.

90 - Hills Landtype Association

1. Comprises or gently rolling lowlands one or more distinctly separate hills.
2. Slopes are less than 1000 feet in length.
3. The slope hydrology originates within these landtypes and there is no contribution from other landtypes at higher elevations except where major rivers or creeks run through continuing valleys.

HILR – Hills – Low Relief

1. Slope gradient is usually greater than 35 percent
2. External relief ranges from 50 to 200 feet.
3. Greater than 60 percent of the map unit is covered by hilly peatland.
4. Usually occur from 0 to 1500 feet in elevation.
5. Landscape may be dissected by gorges 50 to 200 feet deep cut into bedrock.

HIHR – Hills – High Relief

1. Slope gradient is usually greater than 35 percent.
2. External relief ranges from 200 to 1000 feet.
3. Greater than 60 percent of the map unit is covered by tree covered sideslopes.
4. Usually occur from 0 to 1500 feet in elevation.
5. Landscape is commonly dissected by gorges 50 to 200 feet deep cut into the bedrock.

Appendix B

Landslide Risk Assessment Calculation Sheets

Site: MSDI Subalpine veg. Convex upper nonforested shoulder slope

LTA (30)

Criteria	**1**	**2**	**3**	**4**	**Criteria Value**	**Weighting Factor**	**Rating**
Landform							
Slope shape	Vertical	Broken	Convex	Concave-straight	3	5	15
Slope lenght (ft)	0-300	301-700	701-1500	>1500	2	5	10
Slope gradient (%)	May-35	36-55	56-72	>72	3	20	60
Drainage features:							0
Drainage density (% of area)	9-Jan	10-129	20-39	>40	1	10	10
Soils							0
Soil drainage class	WD	MWD	SPD	VP,PD	1	10	10
Soil Depth (in)	>40		20-40	<20	1	5	5
Geology							0
Parent material	Carbonate, colluvium, alluvium	Noncarbonate, granitics, glacial till	Compact till, marine sediments	Volcanic ash	1	5	5
Textural class	Sand, gravel, fragmental loam	loam	silt	silty clay	2	5	10
total of Ratings							125
Failure Hazard Rating							0.4808

*>63,High: 62-50,Moderate; 28-49,low: <28, None; Moderate risk

Site: MSDI Frequently dissected, Upper non-forested sideslope, Somewhat Poorly Drained soil

LTA (30)

Criteria	1	2	3	4	Criteria Value	Weighting Factor	Rating
Landform							
Slope shape	Vertical	Broken	Convex	Concave-straight	4	5	20
Slope lenght (ft)	0-300	301-700	701-1500	>1500	3	5	15
Slope gradient (%)	May-35	36-55	56-72	>72	4	20	80
Drainage features:							0
Drainage density (% of area)	9-Jan	10-129	20-39	>40	2	10	20
Soils							0
Soil drainage class	WD	MWD	SPD	VP,PD	3	10	30
Soil Depth (in)	>40		20-40	<20	1	5	5
Geology							0
Parent material	Carbonate, colluvium, alluvium	Noncarbonate, granitics, glacial till	Compact till, marine sediments	Volcanic ash	1	5	5
Textural class	Sand, gravel, fragmental loam	loam	silt	silty clay	1	5	5
total of Ratings							180
Failure Hazard Rating							0.6923

*>63,High: 62-50,Moderate; 28-49,low: <28, None; High Risk

Site: MSDI	Smooth forested sideslope, Well Drained soil						
LTA (30)							

Criteria	**1**	**2**	**3**	**4**	**Criteria Value**	**Weighting Factor**	**Rating**
Landform							
Slope shape	Vertical	Broken	Convex	Concave-straight	5	5	25
Slope lenght (ft)	0-300	301-700	701-1500	>1500	3	5	15
Slope gradient (%)	May-35	36-55	56-72	>72	3	20	60
Drainage features:							0
Drainage density (% of area)	9-Jan	10-129	20-39	>40	1	10	10
Soils							0
Soil drainage class	WD	MWD	SPD	VP,PD	1	10	10
Soil Depth (in)	>40		20-40	<20	1	5	5
Geology							0
Parent material	Carbonate, colluvium, alluvium	Noncarbonate, granitics, glacial till	Compact till, marine sediments	Volcanic ash	1	5	5
Textural class	Sand, gravel, fragmental loam	loam	silt	silty clay	2	5	10
total of Ratings							140
Failure Hazard Rating							0.5385

*>63,High: 62-50,Moderate; 28-49,low: <28, None;

Site: RAVI Typic Cryaquents, lsk.m Poorly Drained Soils
LTA (40)

Criteria	**1**	**2**	**3**	**4**	**Criteria Value**	**Weighting Factor**	**Rating**
Landform							
Slope shape	Vertical	Broken	Convex	Concave-straight	4	5	20
Slope lenght (ft)	0-300	301-700	701-1500	>1500	1	5	5
Slope gradient (%)	May-35	36-55	56-72	>72	4	20	80
Drainage features:							0
Drainage density (% of area)	9-Jan	10-129	20-39	>40	1	10	10
Soils							0
Soil drainage class	WD	MWD	SPD	VP,PD	4	10	40
Soil Depth (in)	>40		20-40	<20	1	5	5
Geology							0
Parent material	Carbonate, colluvium, alluvium	Noncarbonate, granitics, glacial till	Compact till, marine sediments	Volcanic ash	3	5	15
Textural class	Sand, gravel, fragmental loam	loam	silt	silty clay	2	5	10
total of Ratings							185
Failure Hazard Rating							0.7115

*>63,High: 62-50,Moderate; 28-49,low: <28, None; High Risk

Site: RAVI, Typic Haplocryods, lsk, m; Well Drained soil

LTA (40)

Criteria	1	2	3	4	Criteria Value	Weighting Factor	Rating
Landform							
Slope shape	Vertical	Broken	Convex	Concave-straight	4	5	20
Slope lenght (ft)	0-300	301-700	701-1500	>1500	1	5	5
Slope gradient (%)	May-35	36-55	56-72	>72	4	20	80
Drainage features:							0
Drainage density (% of area)	9-Jan	10-129	20-39	>40	1	10	10
Soils							0
Soil drainage class	WD	MWD	SPD	VP,PD	1	10	10
Soil Depth (in)	>40		20-40	<20	1	5	5
Geology							0
Parent material	Carbonate, colluvium, alluvium	Noncarbonate, granitics, glacial till	Compact till, marine sediments	Volcanic ash	1	5	5
Textural class	Sand, gravel, fragmental loam	loam	silt	silty clay	2	5	10
total of Ratings							145
Failure Hazard Rating							0.5577

*>63,High: 62-50,Moderate; 28-49,low: <28, None; Moderate Risk

D. Fire History of the 6 Mile/Canyon Creeks Watershed

2. Historic Overview

The Kenai Peninsula has a history of infrequent large fires, approximately every 12 years. These have usually taken place on the West half of the Kenai Peninsula. When sustained dry conditions occur in the summer, the fire danger can increase dramatically within a few short days due to long daylight hours. Ignition of fires by lightning is somewhat common on the west side of the Kenai Peninsula, but occurs rarely on the East side. Recreational use of the area accounts for most of the accidental human caused fires under a wide range of conditions. Some abandoned campfires go undiscovered. They go out on their own, or are put out by the public and are not reported.

To date there has not been a problem from intentionally set fires, but that potential exists in any forested area. The greatest fire threat to life and property in the assessment area is probably from an accidental human caused fire starting within or adjacent to private structures, rather than from a fire burning in to structures from the outside.

The pattern of forest succession on the East half of the Kenai Peninsula shows itself in mosaics consistent with a long term fire disturbance cycle, and therefore does not lend itself to simple answers. The cycle is unique to parts of Alaska, and there has been little fire history research done in the area to date. Pre European forest succession to a climax forest was only occasionally interrupted by fire primarily because of wet conditions and lack of natural ignition sources.

Lightning ignited fires, while only somwhat common to the West half of the Kenai Peninsula, are a rare occurrence on the East half. There have been only 3 documented lightning fires on Forest Service lands since 1910. The last, Nelson Creek, in 1997, was in the Sixmile Analysis Area. It went out by itself after 3 days and after having burned $1/10^{th}$ acre. Fires initiated by native peoples probably did occur, but were poorly if at all documented. The Sixmile Analysis area was subjected to considerable burning during the initial stages of the mining era as indicated by the large mosaics of hardwood stands in the area. Some burning was possibly accidental, but the majority was probably purposeful in order to expose bedrock for mining, or to remove slash concentrations after having utilized the timber for mining purposes.

The presence of insect outbreaks, windthrow, avalanche or fire can revert an effected area to earlier successional stages. Fire has the capacity to change the cycle at any point depending upon its intensity, which will not be constant over the entire area of the fire due to differences in fuels, weather, topography and local moisture variations..

"Fires occurred infrequently throughout most forest types in the maritime forests. Most fires were small and probably of little ecological significance. However, large stand-replacing fires occurred at long intervals. Maritime forests in Alaska and wet forests in Canada and the Northwestern United States in the Sitka spruce-western hemlock, Pacific silver fir-Douglas-fir, and mountain hemlock-subalpine fir types may well have burned only rarely, at intervals of 300-500 years or longer".**(12)** In the past, fire regularly cycled through the Alaska boreal forest in 150-200 year cycles.

The Sixmile Analysis Area is included within the boundaries of the Alaska Maritime forest, but closeley borders the boreal forest on the west half of the Kenai Peninsula. The mountains on the west side of the Seward R.D. separate the Kenai Peninsula between maritime and boreal forest, bisected in the center with the predominantly East-West Kenai River drainage. Due to climatic conditions, temperature, rainfall and elevation, the Cooper Landing and Moose Pass areas should be considered a transition area between the two. The Cooper Landing area is considerably drier during most of the year. The Hope, Seward and Girdwood areas should be considered predominantly maritime forest. Evidence of previous fires exist within all timber stands. The probable long term fire return cycle for the Sixmile area is somewhere between 200-500 years. White spruce is considered a fire generated species that usually does not live longer than 200 years in other areas before being replaced by fire. The average age of spruce trees affected by Bark Beetle on the Kenai Peninsula is 190-210 years.

“Evidence of past fires may be seen in the forest communities of the Kenai Peninsula today. This evidence is in the form of fire scars on trees and in relatively even-aged forest stands. In addition, charcoal can be found in the soil of practically every upland forest site. Virtually no upland situations below timberline seem to have escaped fire at some time in the past. It is likely that forest fires have occurred on the Kenai ever since there were forests.” **(20)**

“There seems little reason to label any of the fires within historic times as “first” fires. Even though no written record of any fire earlier than 1851 has come down to us, there is no reason to believe that such did not occur. Climatic conditions and the nature of the forests on the Kenai Peninsula both favor the extensive spread of fires once they are started. Fires must have been started by lightning and human beings long before 1851, just as they are today. If fires were essential to set the stage for the appearance of moose on the Kenai Peninsula there is every reason to believe that the stage was already set, centuries ago.” **(20)**

FIRE PROTECTION STRATEGIES

1. Fire Protection Land Designation

The Alaska Interagency Fire Management Plan has classified and mapped all lands within Alaska as one of four fire protection levels.**(01)** The protection levels determine response, and are used to set priorities for fire fighting resources when Alaska has multiple fires. The Plan also divides the responsibility for wildland fire suppression in Alaska between 3 agencies; the Alaska Fire Service, the State of Alaska Division of Forestry, and the Forest Service. The Forest Service has total responsibility for **wildland** fire suppression within the Sixmile Analysis Area, regardless of land ownership.

a. Critical Protection:

"Areas where human life or habitation are present have priority over all others. Immediate and continuous efforts are made to minimize loss of life and damage to property".**(02)**

The majority of the timbered stands within the Sixmile Analysis Area are in "Full Suppression", whereas the areas above 1,500 feet are in "Modified or Limited Suppression". "Critical Suppression" areas within the Sixmile Analysis Area are limited to Upper and Lower Summit Lakes, Granite Creek Campground, Bertha Creek Campground, the communities of Hope and Sunrise, the immediate vicinity surrounding individual structures within the area.

b. Full Protection:

"Valuable resources, such as commercial timber stands and historic structures exist, but no human life or habitations exist in these areas. Immediate and aggressive action is taken to limit the numbers of acres burned".**(02)**

c. Modified Action:

"Uninhabited; with resources of lesser value. Land managers consider trade-off of acres burned versus suppression expenses. Fires during critical burning months are attacked, but a lower level of protection is provided when the risks of large damaging fires is less".**(02)**. Lands classified as "modified" **may** convert to "limited" after the normal mid July rains during a "normal" fire season.

d. Limited Action:

"Areas where natural fires are beneficial, or where the costs of fighting the fire are greater than the fire damage. Suppression efforts are limited to keeping a fire within a designated area, or protecting critical sites within the areas".**(02)**

V. KENAI PENINSULA FIRE SUPPRESSION CAPABILITIES

Regardless of the fire protection designation, protection of life and property will always be the first priority of fire suppression efforts. Should weather or fire situations change, any new threat to life and property will take precedence over an ongoing wildland fire suppression effort where life and property are not threatened. With a limited number of fire suppression people and equipment immediately available on the Kenai Peninsula, this could well mean that during the initial attack phase, firefighters would respond to structure protection. Wildfire suppression would have to wait. The fire would grow and spread until additional resources arrived. Once a fire has gone beyond the capabilities of the initial attack fire crews, full transition to a Type II or Type I Incident (Fire) Management Team could take 24 hours, with full implementation of a large fire suppression strategy taking an additional 24 hours. This was exactly the case on the North Shore Kenai Lake fire in 2001.

Current initial attack fire suppression capabilities on the Kenai Peninsula have been adequate to date. They have often been called upon to deal with more than one fire per day, or several fires concurrently. Fires on the West half of the Kenai Peninsula have historically been larger, as they originated in black spruce, which is a more volatile fuel than found in the higher elevations of the eastern half. Black spruce can have fire behavior similar to California Chapparal. The West half of the Kenai Peninsula also has a history of occasional lightning fires.

1. State

During fire season, the State of Alaska Department of Forestry fields two-250 gallon engines at Soldatna staffed by 2-4 people each, an additional 500 gallon slip on unit at Soldatna which can be sent to Homer during periods of
high fire danger, one 1,200 gallon engine tender at Soldotna, and one-250 gallon engine at Homer staffed by 2-4 people. There is also a light turbine initial attack helicopter and 2 person crew also stationed at Soldatna. Units at Homer would be unlikely to be used on Forest Service lands, but could be used to cover the State protection areas while Soldatna forces are moved.

State Initial attack resources and budgets are not projected to increase on the Peninsula at this time. A 100 person fire cache (fire support equipment) is available at Soldatna. The Department of Forestry can also field up to 50 Emergency Firefighters on the Kenai Peninsula within 24 hours. Airtankers with retardant are available at Palmer and Fairbanks.

Aerial retardant mixing bases exist in Palmer and Kenai, with a portable mixing base available at Homer.

2. Federal

a. Chugach National Forest

The Seward Ranger District fields 6 initial attack firefighters dedicated specifically to fire suppression during the average 150 day annual fire season. Each works 5, eight hour days per week due to extended Alaska daylight, and staff one-200 gallon engine with a (WEPS) Water Expansion Foam System and one-75 gallon engine with a slip on unit. A 20 person fire cache (fire support equipment) is available at Kenai Lake Work Center. Under normal fire weather conditions, 3-4 firefighters are on duty on any given day, and additional people are brought on when the fire danger climbs. (9.)

Funding for the Fire Crew is based on the National Fire Management Analysis System (NFMAS), programmed for the Seward R.D. NFMAS is a National fire suppression budgeting system approved by Congress separate from other federal budgets, and is based on the District's most efficient level of initial attack. It is designed to allow Congressional approval of Federal Fire budgets 2 years in advance. It is unlikely that Seward's normal fire budget will allow increased personnel beyond its present capabilities unless the District has significant increased numbers of fires and acres burned on Federal land. A fire analysis of the Seward Ranger District in 1995 for the previous 10 years indicated that 58% of all fires within Forest Service protection jurisdiction were on State and private lands. Severity funding is available to hire more firefighters if the fire season becomes unusually severe. Additional trained firefighters are available from the Seward and Glacier Ranger Districts within 1-3 hours, and from the Cordova Ranger District within 3-5 hours. The Forest Service also jointly funds the Alaska Dept. of Natural Resources initial attack fire helicopter at Soldatna, and the airtanker stationed at Palmer.

b. Kenai Fiords National Park

Kenai Fiords National Park has no fire suppression equipment, and no designated firefighters. A limited number of people are available for wildfire suppression by request only. Responsibility for fire suppression within the Park resides by Interagency agreement with the Chugach National Forest, and specifically the Seward Ranger District.

c. Kenai National Wildlife Refuge

Kenai National Wildlife Refuge has some fire suppression equipment used for prescribed fire, and a limited number of people available for wildfire suppression; available by request only. Responsibility for fire suppression within the Refuge resides by Interagency agreement with the State of Alaska Department of Forestry.

3. Community Fire Departments

Several local communities have developed Volunteer Fire Departments for structural fire protection. All listed are either currently under agreement with the Chugach National Forest, Seward Ranger District, or an agreement is pending, to provide additional initial attack on wildland fires on State, Private and Federal land within the designated response area of the individual departments. All listed are also potentially available for structural fire protection within the remainder of the Kenai Peninsula area upon request by the Forest Service in the event of a wildland fire threatening structures. Due to the need to provide structural fire protection to their respective communities, not all equipment and personnel could or would likely be made available at one time. Response times vary. Many volunteers work in areas outside their local community and commute over long distances. Listings only show the maximum paper capability of their respective departments.

a. Bear Creek Volunteer Fire Department

The Bear Creek Volunteer Fire Department could potentially field on request, a maximum of one-250 gallon engine, one-300 gallon engine, one-500 gallon engine, two-2,000 gallon engines, one-3,000 gallon engine, and 41 firefighters.

b. Cooper Landing Volunteer Fire Department

The Cooper Landing Volunteer Fire Department could potentially field on request, a maximum one-250 gallon engine, two-2,500 gallon engines, one-500 gallon engine, one-110 gallon engine, and 19 firefighters.

c. Girdwood Fire Department

The Girdwood Fire Department could potentially field on request, three-1,750 gallon engines, and 12 firefighters.

d. Hope/Sunrise Volunteer Fire Department

The Hope/Sunrise Volunteer Fire Department is currenly negotiating an agreement with the Forest Service and could potentially field on request after agreement signature, a maximum of one-500 gallon trailer, one- 250 gallon trailer, and 27 firefighters.

e. Lowell Point Volunteer Fire Department

The Lowell Point Fire Department is currenly negotiating an agreement with the Forest Service and could potentially field on request after agreement signature, a maximum of one-250 gallon engine and 6 firefighters.

f. Moose Pass Volunteer Fire Department

The Moose Pass Volunteer Fire Department could potentially field on request, a maximum of one-250 gallon engine, one-500 gallon engine, one-1,000 gallon engine, one-2,000 gallon engine and 18 firefighters.

g. Seward Fire Department

The Seward Department could potentially field on request, a maximum of 0ne-2,500 gallon engine, one-1,000 gallon engine, two 500 gallon engines, one 750 gallon engine, one-200 gallon engine, and 38 firefighters.

VI. WILDLAND FIRE AND FIRE SUPPRESSION EFFECTS

Wildland fire is a natural part of the ecosystem, and can have both positive as well as detrimental effects, depending upon location and fire intensity. The 1910 fires which burned most of the State of Idaho in one summer caused a boom in elk populations that was on the decline by the 1980’s decade. Due to a series of large fires in Idaho in the 1990’s decade, elk populations are once again on the increase. Moose populations increased on the Kenai Peninsula after the large fires of the early 1900's.**(34)** Fire makes nutrients locked up in dead fuels available for new growth. Fires can also remove habit necessary to species survival. Intense fires can volatilize nutrients into the atmosphere, taking years to replace.

Years of fire exclusion (suppression efforts), in fire dependent ecosystems are currently causing ecosystem backlash in several areas of the lower 48 states. Areas which historically burned once on the average of every 10-12 years with low intensity, have not been allowed to burn for 85-95 years. Natural fuels have built to the point where the fires that do generate, rapidly become large, intense, and result in extreme resource damage with extremely high suppression costs. Increased building in the wildland/urban interface during the same period, has for the last 10 years resulted in major losses of structures and some lives annually due to wildfires.

Forests dependent upon fire to maintain health are stressed and dying of drought and insect infestation as a response to fire suppression. When they burn now, they are frequently burning with such intensity that the stand is replaced, not maintained. The sites are reduced to growing earlier successional stages. Once a stand replacement fire occurs, the area is generally fireproofed for many years. There are similarities between what is going on in areas of the Western United States, and what is happening on the Kenai Peninsula with the spruce bark beetle epidemic. The fire histories are different, but the local results can be the same. The current spruce bark beetle epidemic is generating large quantities of hazardous fuels buildup. Under the right conditions, they can burn intensely.

Thirty one permanent plots were established in 1976 in the Resurrection Creek drainage of the Chugach National Forest, by Forest Health Management and Forest Research personnel to study impacts of increasing spruce beetle populations. In 1994, 13 of those plots were again surveyed to establish current fuel loadings. Seventeen of the original plots were lost to a prescribed burn for moose habitat improvement. The results of the second survey were that duff depths decreased, while total fuel loadings, fuel height and percent grass cover increased. The 0-0.25 size class fuels increased .14 tons to the acre. The 0.25-1 inch fuels increased .44 T/A. The 1-3 inch fuels increased 1.24 T/A. The 3 inch plus sound fuels increased 22.84 T/A. The 3 inch plus rotten fuels decreased 1.27 T/A. Duff depth decreased 1.6 inches. Fuel height increased 4.74 inches. Calamagrostis grass increased 50%. The total increase in dead and down fuels was 25.5 tons per acre, leaving the **average** plot accumulated total at 35.38 tons per acre.**(27)** Even in wet climatic areas, fuel loadings above 12-14 tons per acre are considered to be at hazardous levels during fire season. Increases in fine fuel loadings which contribute to rate of fire spread were minimal, but were offset by the increase in grass cover from 0-2% to 50%. Large diameter fuels which contribute to high fire intensity underwent the greatest increase.

Fire burns more intensely on steeper slopes due to preheating, and can reduce the lower duff layer to mineral soil. High mineral soil exposure on steep slopes can cause major erosion during rains. Intense rains immediately after a fire can cause soil saturation to the point where mass failure occurs in creek headwalls. Intensely heated soils can also become impermeable to water, causing almost total runoff during rain. In the vicinity of creeks and riparian areas, high concentrations of high acid content ash from a fire can immediately be made available in the water, taking one to two days to clear up, but causing fish kill and sedimentation downstream. The Kenai Peninsula is one of the highest salmon producing regions in the State of Alaska. A large intense wildfire in the area at an inopportune time can have a detrimental impact on native fish, and specific salmon runs.

Fire suppression efforts can have detrimental effects of their own. The threat to life and property takes precedence over fire suppression. With a major fuel buildup, fires in the assessment area have the potential to become larger, threatening property, and requiring the use of heavy equipment such as dozers and airtankers to stop them.

Dozer use is often necessary to stop large wildfires, but can cause serious erosion potential to fragile soils. Rehabilitation efforts can take years, and still leave visible scars.

Fire retardants dropped by airtankers are often necessary to slow fires down so that hand crews can take direct attack, but all in current use are chemical fertilizers. Phosphates, one major ingredient, have caused algal bloom in lakes, as either a direct result of a miss into a stream or lake, or as a result of later runoff. Another direct result has been localized fish kill. Retardant dropped by aircraft has been used on the Seward Ranger District previously, and is considered a viable suppression option.

The possibility of detrimental results of wildfire or wildfire suppression actions need to be considered in terms of specific resources effected in the assessment area. The Seward R.D. fire crew implements minimum impact fire suppression techniques whenever practical during initial attack. Suppression on larger fires requires priorities established in writing by the District Line Officer, and may require local Resource Advisors assigned to the Team to ensure that specific resourse values are protected during suppression efforts.

VII. AIR QUALITY

"Fires emit small particles, organic vapors, carbon monoxide, and water vapor. The quantity and type of combustion products is dependent on the amount and type of fuel burned, the amount of air (oxygen) around the fuel, and the combustion temperature. Fires with insufficient air produce relatively large amounts of particles, organic vapors, and carbon monoxide. "Cool" burning fires produce relatively large amounts of these pollutants.

As these compounds are emitted, they disperse in the surrounding air and are carried off by the wind. The concentration of these products in surrounding areas is basically dependent on the quantity emitted, wind direction, wind speed, ambient temperatures, and inversion layers.

Some of the products emitted from a forest/brush fire can cause health problems. The most apparent problem is related to short-term exposure to respirable particles (smoke). People with lung diseases (e.g., asthma or bronchitis) are especially sensitive to smoke. Several individuals known to have these conditions reside within the Cooper Landing area. Some of the combustion products are known or probable carcinogens."**(01)**

The Environmental Protection Agency has established health standards, called National Ambient Air Quality Standards, for emissions such as smoke. The 24 hour health standard for smoke is 150 micro grams per cubic meter, and is measured as PM10 (particulate matter 10 microns in diameter and smaller). It is those particles that get into lungs and impair the respiratory system. Those at highest risk are firefighters. Evidence from recent health testing at the national level indicates an increased hazard from smoke. Discussions are underway to possibly amend the Clean Air Act and change PM10 to PM2.5.

"The smoke produced by burning vegetation may also temporarily interfere with air and surface travel. Visibility along roads can be reduced to hundreds of feet in the vicinity of a fire. Aircraft operations can be affected if smoke reduces visibility to less than 6 miles.

The Alaska Dept. of Environmental Conservation is the regulatory agency responsible for air quality and smoke management on both state and federal lands in Alaska. Management-ignited prescribed burns, other than burning to combat a wildland fire, requires written approval from the department.

Concerns about public health related to air quality and visibility are considered in actions taken within all fire management option areas. Air quality and visibility impacts are also considered during the preparation of the Wildland Fire Situation Analysis and the selection of the appropriate suppression strategy for fires that escape initial attack."**(01)**

VIII. FIRE BEHAVIOR FUEL MODELS

A total of 8 fire behavior fuel models were identified from the Cooper Landing Environmental Assessment by John See **(28)**. The following fuel model narratives in increasing order of fire intensity describe the local fuel types present within the Chugach National Forest on the Kenai Peninsula. Acreages designated are total acreages of that fuel type present on Forest Service Lands circa 1996.

One chain equals 66 feet. Flame lengths 6 feet or longer cannot be safely attacked by hand crews with tools:

1. Fuel Model 00: No fuels-365,500 acres, water-36,100 acres, no data-200 acres. This model was developed to
represent a no fuels condition, such as water, icefields, rock outcroppings, etc.

2. **Fuel Model 0**: 280,000 acres. Fire resistant vegetation (high elevation moss).

3. **Fuel Model 2:** 10,500 acres (easily contained). Fuel model 2 represents a grass fuel type beneath an understory of timber, including spruce, spruce hardwood mixed and hemlock in varying combinations. The key element in this model is that grass carries the fire, not forest litter. Timber stands are sparse but have at least 1/3 coverage of the area in this model. Fire behavior is characterized as having relatively fast rates of spread with moderate intensities until wind is applied, then expect intense fires that outrun all suppression efforts causing a severe threat to life and property. This is a seasonal model becoming progressively less burnable following green-up. One slightly higher than surrounding open areas due to the shading afforded by the overstory. Because of the amount of defoliation in the overstory in the assessment area, this is not totally true. (With a windspeed of 5 mph and a moisture content of 8 percent, representative rates of spread are 35 chains per hour with a flame length of 6 feet).

4. **Fuel Model 3:** 58,800 acres (easliy contained). Fuel model 3 represents a grass fuel model without any overstory. The primary species is Calamagrostis canadensis which is a coarse, tall bunchgrass that burns intensely, particularly when wind is applied. Like fuel model 2, associated fire behavior includes rapid rates of spread causing a severe threat to life and property. A characteristic of this model in Alaska is that our normal winter snowfall packs down the fuel compressing it to a fraction (1/2 or more) of the depth during the previous fall. This lowers the flammability of this model rapidly as the season progresses (early June). This fuel model is commonly found in areas where timber harvest has occurred in southcentral Alaska and scarification or herbicide treatments have not been utilized. (With a windspeed of 5 mph and a moisture content of 8 percent, representative rates of spread are 104 chains per hour with a flame length of 12 feet).

5. Fuel model 6: 216,300 acres (moderately difficult to contain). Fuel model 6 represents primarily shrub tundra vegetation type comprised of mainly dwarf birch, willow, young alder and other shrubs. This model is generally not a problem until dry conditions prevail in Alaska and then only when wind plays a significant role in fire spread and behavior.

The wind reduction factor, used for converting 20 foot wind speeds to midflame windspeed is .75 for this model, the highest for all Alaskan fuel models. This model also deserves healthy respect when it comes to fire behavior. Rapid rates of spread and high intensities are the rule which causes a threat to life and property, especially in and around the urban wildland interface. (With a windspeed of 5 mph, a fuel moisture content of 8 percent, and a live fuel moisture content of 100%, representative rates of spread are 32 chains per hour with a flame length of 6 feet).

6. **Fuel Model 8**: 232,900 acres (moderately difficult to contain) Fuel model 8 represents a predominant timber overstory with a typical forest litter understory. The vegetation type in the area that best fits into this classification includes; healthy or lightly attacked spruce stands, hardwoods, hemlock and some of the mature stands of alder. Fire behavior is typically low, so low in the case of hardwoods that they can generally be relied upon as fuel breaks, unless drought conditions prevail. Then expect low intensity, creeping fires that do not pose a direct threat to life and property. (With a windspeed of 5 mph, a fuel moisture content of 8 percent, and a live fuel moisture of 100%, representative rates of spread are 1.6 chains per hour with a flame length of 1.0 feet).

7. Fuel Model 9: 730 acres (difficult to contain) Fuel model 9 represents a very small amount of black spruce in the area. This type is extremely volatile mostly due to the low live fuel moisture in this species. Fire behavior is generally represented by moderate rates of spread with low intensities, however, prolific torching and spotting is the rule with this model, transforming it into Dr. Jekyll and Mr. Hyde types of fuel. At low humidities and average winds, fires in this type are very difficult to suppress. A correction factor of 1.21 must be used to reflect the rate of
spread and fuel model 5 (NFFL) must be used to represent intensities correctly. (With a windspeed of 5 mph a fuel moisture content of 8 percent and live fuel moisture content of 100%, representative rates of spread are 7.5 chains per hour with a flame length of 2.6 feet).

8. **Fuel Model 14:** 2,600 acres (difficult to contain). This fuel model is a custom fuel model developed in the Newmodel/Testmodel section of the BEHAVE computer program, and is non-standard. This type represents white spruce that has been attacked by spruce beetles within 5 years. A small component of live woody fuels are present which will increase dramatically as the stand opens up (see model 22). In relative ranking, this fuel model is hotter than fuel model 8, but significantly cooler than the grass and brush models. Rates of spread and intensities are manageable by firefighters in the full range of conditions, including winds. Exceptions apply to large jackpots (accumulations) of heavy fuels.

9. **Fuel model 22:** 25,700 acres (difficult to contain) Fuel model 22 is a custom fuel model developed utilizing BEHAVE to create a non standard model that represents fire behavior in the white spruce stands that were attacked by spruce beetle over 5 years previously. Fuel loadings in these stands are adjusted to reflect increased loadings as the standing dead trees begin to fall and more grass and brush becomes established in the understory. This sequence varies from place to place. In some areas, a younger stand of white spruce that the beetles passed over is hit a decade or so later. The end result is generally the same, more live herbaceous and live woody loadings in

addition to increases in the 10 and 100 hour (and larger) fuel classes. This model was created liberally to show if anything, higher fire behavior to remain on the conservative side. There could be points in time, however, that fuel model 2, 3, or 6 would be more appropriate. The spruce stands in the Sixmile Analysis Area are are predominantly within Fuel Model 22.

VIII. FUELS TREATMENT

Treatment of hazardous levels of fuels is the most pro-active method of breaking the fire behavior triangle of fuels, weather and topography. Weather and topography cannot be modified. Methods which deny a fire's access to continuous fuels, or modify existing fuel loadings in such a manner that what remains is less flammable, or burns with reduced intensity, will reduce the resistance to control of a wildfire, and reduce the ultimate costs of fire suppression. Stands can be replaced with less flammable species. Fuel treatment methods are expensive. Site specific fuels prescriptions are designed to produce maximum cost effectiveness for the results they are expected to provide. Fuels treatment where appropriate has **always** been found to be more cost effective than fire suppression, and more acceptable than living with adverse resource impacts of either a wildfire, or a wildfire suppression effort, or both.

Natural fuels are those which build up through natural processes. Activity fuels are those which accumulate as a by product of logging or management activity. Natural and activity fuels treatment projects have, and are taking place on the Seward Ranger District in the Analysis Area.

The array of fuels treatment options for natural fuels is identical to that of activity fuels. Differences can be measured by the level of effectiveness, the cost, and the numbers of acres treated over time. Access and treatment type determine ultimate cost. If access is not present, another less effective form of fuels treatment may have to be substituted to keep the project cost effective.

The major difference between the treatment of natural versus activity fuels on the Kenai Peninsula, is that access restricts the treatment of most natural fuels to only the fines, and not the large diameter boles which will later come down and be available to contribute to high fire intensity levels and resistance to control. Underburning natural stands, a highly viable and effective method of fuels treatment in a number of areas, is not effective in Alaska where all tree species have thin bark and would be killed by the passage of fire.

1. Fuels Treatment in Natural Stands

a. Fire Breaks

Fire breaks are planned fire control lines installed prior to an actual fire. They are useful in areas with flashy fuels subject to short interval fire returns, and are generally 1 or two dozer blade widths wide, cut to mineral soil and located on topographic features which assist in stopping fire spread. While effective, they are unattractive from a visuals standpoint, have a high degree of required maintenance, and can cause erosion problems. Fire breaks are not recommended for the Fuller Area, as the fire return interval in the area has been historically long term, and would not justify the initial cost, the long term maintenance expense, the potential erosion problems, or the degradation of the visuals.

b. Shaded Fuel Breaks

Shaded fuel breaks are areas where fuels have been removed to slow the spread of ground fire. Trees have been removed to make the canopy discontinuous and not conducive to crown fire. Removal of the fuel is generally accomplished by piling and burning. Standing dead trees are dropped, and dead and down fuels are piled. The limbs of remaining live trees are removed up to 12-14 feet in height in order to remove ladder fuels and keep fire on the ground. Dense stands of live trees are thinned to make a discontinuous canopy. Sufficient live trees need to be retained to provide shade, which maintains lower surface temperatures and higher fuel moistures. Discontinuous canopies also allow aerial retardant application to be more effective. Low live brush is also removed. Fuel breaks do not stop fires, they merely slow them down long enough to allow hand crews time to establish control lines within the fuel break. <u>Minimum</u> standards for effective shaded fuel breaks are 300 feet wide. Fuel breaks are a viable option to provide fire protection for any community in forested areas subject to periodic wildfires. The projected beetle kill in the

Moose Pass area makes utilization of shaded fuel breaks a reasonable option. Opening the canopy will also increase sunlight, which can have the negative consequence of stimulating growth and spread of Calamagrostis canadensis, a fine flashy grass fuel. Planting fuelbreaks with hardwoods, or a less flammable species of native grasses which competes with Calamagrostis might be an option.

c. Isolation

Isolation consists of allowing nature to reduce hazardous levels of natural or activity fuels through the process of decomposition. Crushing by snow pack, and high rainfall and moist conditions assist the process. This is normally acceptable where the hazard rating is borderline, potentially short term, or where other fuels treatment methods are not cost effective. Isolation can also be assisted by breaking large blocks of continuous fuels into smaller more manageable areas with fire breaks or fuel breaks. Since lightning ignition of fires on the East half of the Kenai Peninsula is uncommon, isolation would be a viable fuels treatment alternative in some mixed conifer stands in the assessment area beyond 1/4 to 1/2 mile from roads and trails. Due to the risk of ignition by humans, isolation of areas within 1/4 mile of access routes would be impractical. Isolation is the cheapest fuels treatment option in the short term, but is a gamble with associated risks, and can become an expensive mistake in the long term if exposed to an ignition source.

d. Prescribed Burning of Natural Fuels.

Burning infected and dead spruce stands will remove fine fuels in the crowns of standing timber, reduce quantities of dead and down fuels on the ground, and expose areas to mineral soil for seed beds, providing the prescribed fire is of sufficiently high intensity. Low intensity prescribed fires can remove competition and contribute to the spread of Calamagrostis canadensis. There are no fire tolerant, or fire resistant tree species on the Kenai Peninsula. All species present are thin-barked, and live tree mortality can be expected to be 100% when in direct contact with fire for more than short duration. This would include all remaining small diameter spruce that have not been attacked by bark beetle.

Prescribed burning of conifer stands should result in reducing the potential for high intensity wildfires for several years, and would also be expected to induce hardwood growth on the site, providing increased big game browse. Hardwoods within the stands will also suffer 100% tree mortality, but moderate burning conditions can stimulate new hardwood growth by basal sprouting. Decadent hardwood stands resist basal sprouting from fire.

Burning natural stands within the assessment area is a viable option. However, the risk of an escaped prescribed fire also has to be considered. The cost of a prescribed fire, including measures taken to maintain control, must also be worth the projected return in terms of fireproofing the stand and other benefits. Fire season and prescribed fire season occur during the same months on the Kenai peninsula. Some years are simply too wet to burn and achieve acceptable results. Some years rapidly become too dry to accept the risk of escaped prescribed fires. Large acres projected to be burned produce large volumes of smoke. Opportunities to burn can be reduced by smoke management constraints.

One potential disadvantage of burning standing dead trees, is that the boles will not consume except under extreme burning conditions, and will eventually make it to the ground in jackstraws. This can increase the potential resistance to control of any later wildfires within the area. Jackstrawed timber also inhibits the movement of big game animals.

2. Fuels Treatment in Activity Fuels

Activity fuels are those fuels generated by logging or management activity. Logging systems on the Kenai Peninsula are most often ground based systems using machinery. Tree boles are removed, leaving only unmerchantable tops and branches (slash), behind, or are full tree yarded to the landing, leaving behind only breakage and pre existing fuels. Slash is dealt with at the landing.

Pre-existing fuels and the majority of slash normally remains on the site, with some being removed to the landing. Without further treatment, the remaining slash constitutes high hazard fuels for the local site. Removal of dead spruce tree boles would reduce the potential intensity of any fire within a local area, as well as spotting potential and resistance to fire suppression efforts. Removal or reduction of the 0-3 inch size class fuels reduces the highest potential for increased fire intensity, and decreases its rate of spread.

The cumulative effect of logging large discontinuous areas without doing slash treatment has time and again shown that fire starts spread rapidly in slash through aerial spotting from untreated area t untreated area, increasing the size, the suppression complexity, and the ultimate cost to taxpayers. One fire of a specific size has less perimeter to hold, requiring less people and equipment, than five fires of the same total acreage. In the long term, fuels treatment always proves cheaper and more effective than fire suppression. Fire starts in treated fuels have low rates of spread and low intensities, which are easily dealt with by initial attack fire crews.

Fuels treatment can mitigate some of the potential for major wildfires in the Sixmile Analysis Area, by providing areas where fires would slow down and decrease intensity, and be stopped more readily by fire crews and equipment. Scarification through piling can provide seed beds, promoting new growth of hardwoods, and providing shade and live fuel moisture which slows rates of fire spread. Roadbeds and skid trails created by machine piling and removing firewood to landings, whether permanent or temporary, can provide fire breaks where fire suppression efforts can be anchored.

"If Calamagrostis grass is found in every square meter in the understory prior to cutting and piling, there will be rapid spread when the stand is clear cut unless clones are killed using herbicides or a deep burn. Alternatively, the shade provided by a natural canopy may inhibit the grass sufficiently to allow spruce seedlings to establish. If grass is not abundant in the understory, (1) minimize forest floor disturbance to reduce sites for grass colonization or (2) a slash burn with the hope of encouraging colonization by herbaceous species that have less impact on conifer seedlings."

a. Winter treatment

Winter treatment allows the opportunity to remove the overstory timber without damage to sensitive features or advanced regeneration, but has the disadvantage of leaving untreated pre-existing fuels below the snow, and does not allow scarification, which prepares a seedbed for natural regeneration of hardwoods and conifers. This makes the site more difficult to reforest.

b. Summer treatment

Summer treatment allows treatment of all available fuels, and allows the possibility of scarification for seed bed preparation. It may also have negative impacts on sensitive plants, soils, and cultural sites which would be unacceptable.

c. Chipping

Chipping of slash on site, or whole tree yarding and chipping slash at the landings are viable options in the Assessment Area where designated and are accessible to mechanized equipment. Slash less than 3 inches in diameter contributes to fire spread. Fire smolders slowly in chips. Slash that has been chipped should be spread, and where possible mixed with mineral soil. Mixing assists in decomposition of the chipped material. Piles of chips, or chips spread too thick will insulate the soil to make it a colder site, and inhibit tree growth.

d. Lop and Scatter

Small diameter material is cut in short pieces laid directly on the ground, and concentrations scattered. Slash is later crushed to the ground by winter snow levels and decay through natural degeneration takes place. Lop and scatter is a viable option in higher elevations of the assessment area when most down material is less than 3 inches in diameter, and total dead and down material is discontinuous or in small enough quantities that projected fire spread would be low. Lop and scatter is largely ineffective in dense natural stands, but can be effective in activity fuels where slash concentrations are small and discontinuous.

e. Piling and Burning

Piling and burning of activity fuels should be considered the most practical option for fuels treatment in the assessment area. Whether piled by machine or hand, as long as the piles have been covered, they can be burned outside of normal fire season when risk of escape is minimal. There is also sufficient opportunity to burn them in the Fall with less projected constraints in terms of smoke management.

Machine piling and covering should be considered as one of the most economical forms of fuel treatment in terms of cost per acre, with the least associated risk of unacceptable results.

Hand piling and covering, while the most practical form of fuel treatment for some locations, is also the most expensive form of fuel treatment existing in terms of cost per acre, as it is the most labor intensive option. Burning piles concentrate sufficient heat to expose mineral soil and discourage the growth of Calamagrostis grass. They provide open sites for planting trees and natural regeneration. One major advantage of piling and burning is that residual small diameter spruce currently unaffected by bark beetle, can be retained.

Leaving a limited number of piles per acre without burning has little impact on overall fuels treatment objectives, and has definite benefit for some wildlife species. However, those piles identified to be left for wildlife purposes should not be in close proximity to human travel routes.

f. Broadcast Burning of Activity Fuels.

Broadcast burning of activity fuels removes the 0-3 inch size class fuels which contribute to rate of spread and intensity, and allows more overall control. The ability to achieve acceptable results is more probable, and more predictable than with burning standing timber. Techniques are more refined, and more research has been done on results. Spotting is less likely. Fire intensities in continuous slash can be manipulated to remain high enough to discourage the growth of Calamagrostis grass, while still retaining a necessary lower duff layer, and quantities of large diameter fuels necessary for long term site productivity and wildlife needs. Risk of escape is more easily mitigated than with burning natural stands, but there is still a higher risk of an escape.

Any consideration of broadcast burning within the Assessment area should start by breaking the areas up into small easily controlled units, fully surrounded by machine fireline when possible and hand fireline when not.

Wildlife

Nearly 200 species of wildlife are found on the Kenai Peninsula and may be present in the watershed. The following list of TES, MIS, and SSI for the Chugach National Forest are listed in the Revised Land and Resource Management Plan, Final Environmental Impact Statement (2002).

Table 1. MIS, TES, and, SSI on the Chugach National Forest.

SPECIES	MIS	TES	SSI
Brown Bear	X		
**Black Oystercatcher*	*X*		
**Dusky Canada Goose*	*X*	*X*	
Moose	X		
Mountain Goat	X		
Gray Wolf			X
Lynx			X
Marbled Murrelet			X
**Montague Island Hoary Marmot*			*X*
River Otter			X
Sitka Black-tailed Deer			X
Townsend's Warbler			X

Wolverine		X
Bald Eagle		X
Humpbacked Whale (Endangered)	*X*	
Montague Island Tundra Vole	X	
Northern Goshawk		X
Osprey		X
Peale's Peregrine Falcon	X	
Steller Sea Lion (Endangered)	*X*	
Trumpeter Swan	X	
Steller''s Eider (Threatened)	X	

The species listed in italics above do not occur on the Seward Ranger District or in the project area for the reasons listed below, and will not be analyzed further.

Based on Table 4-48 of the Revised Land and Resource Management Plan, Final Environmental Impact Statement, habitat for the MIS species **Black oystercatcher** and the **Dusky Canada Goose** do not occur on the Seward Ranger District, but only on the Copper River Delta or Prince William Sound

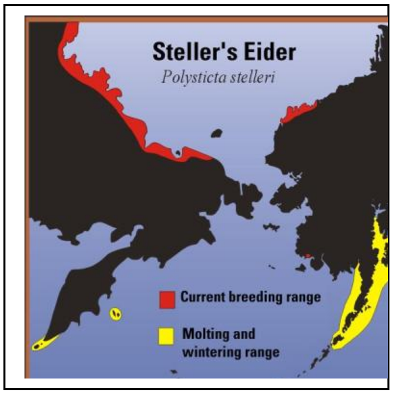
Based on Table 3-50 of the Forest Plan, the Kenai Peninsula does not have rocky coasts, sheltered inshore waters, or beach association habitats suitable for the **Steller's Sea Lion**, or **Black oystercatcher**.

The **Sitka black-tailed deer** (*Odocoileus hemionus sitkensis*) is native to the wet coastal rain forests of Southeast Alaska and north-coastal British Columbia. Transplants have expanded its range, and established populations now also exist near Yakutat, in Prince William Sound, and on Kodiak and Afognak islands. Table 3-50 of the Forest Plan lists Sitka Black-tailed deer as occurring only in the Prince William Sound area. On occasion, individuals in Seward report seeing deer in the area. They may rarely occur on the district, but are not suspected to survive the winters here (personal communication with Bill Shuster, SRD wildlife staff).

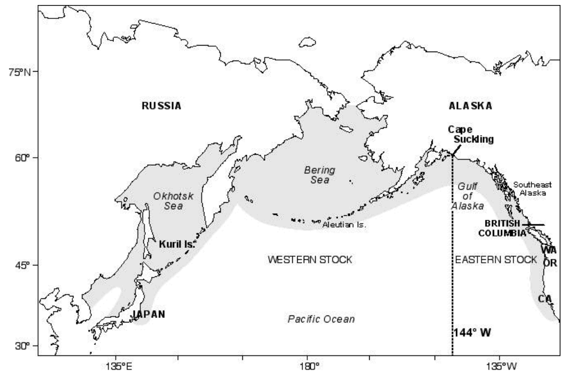
The **Montague Island Tundra Vole** and **Montague Island Hoary Marmot** are endemic to Montague Island, and are not expected to occur on the Kenai Peninsula.

The **Humpbacked Whale and Steller's Sea Lion** are endangered marine mammals that occur within the boundaries of the Chugach National Forest. Marine habitat and sea lion rookeries do not exist within the project area, nor will they be affected by project activities. The most recent aerial survey of Steller sea lions in Alaska was conducted in June 2000 by the USFWS. I reviewed the Technical Memorandum that presents survey results for 1999 and 2000.

Steller's Sea Lions range map



Map 1: Steller's Eider Range



Map 2: Stellar Sea Lion Range

***Steller's Eider** does not breed on the forest. Its wintering range occurs on the south end of the Kenai Peninsula, but not on the Seward Ranger District according to the US Fish and Wildlife Service's distribution map (See Map 1).

This species may occur during migration, but is not known to breed on the district.

The **Peale's peregrine falcon's** range is north of the Seward District, and they are not expected to occur except potentially during migration. In addition, their primary habitat, cliffs along the coast, does not occur on the district.

<u>TES, MIS, and SSI of the Six-Mile Watershed</u>

The following species are either known to occur or potential habitat may exist in the Six Mile Watershed.

Table 2. MIS, TES, and SSI which may occur in the Six Mile Watershed

SPECIES	MIS	TES	SSI
Brown Bear	X		
Moose	X		
Mountain Goat	X		
Gray Wolf			X
Lynx			X
Marbled Murrelet			X
River Otter			X
Townsend's Warbler			X
Wolverine			X
Bald Eagle			X
Northern Goshawk			X
Osprey			X
Trumpeter Swan		X	

TES Species

A. Trumpeter Swan

The Trumpeter Swan is the only TES species, which may breed in the watershed. They are a sensitive species only known to nest on the forest on the Copper River Delta and Twenty mile drainage on the Kenai Peninsula. It has not been confirmed to nest on the district, although it stops during migration, and some pairs remain here during the breeding season. There is one report of swans nesting west of Placer Creek on the forest boundary with the Kenai Fiords National Park (personal communication with Steve Schafer, local pilot who noted seeing them with young present during several years). Nest surveys have not been conducted on the district. The best potential habitat comprises larger bodies of still fresh water at lower elevations that provide sufficient area to take off from the water, and a suitably long nesting period. These conditions occur at Tern Lake, and swans are known to use Tern Lake during spring and fall. They have been seen during the breeding season adjacent to Nash Road. Bench Lake, Summit Lake and Lower Summit Lake offer the only potential habitat in the Six Mile watershed, and swans are not known to use these areas. They are regular at these lakes in the fall migration however, staying until iceup, generally around mid October.

Management for the Six Mile watershed should include aerial surveys of all water bodies in and adjacent to the watershed during the breeding season, and nest protection (0.5 mile buffer) as identified in the forest plan if nests are located.

Management Indicator species are the moose, brown bear and mountain goat. The management indicator species are used to direct implementation, inventory, and monitoring activities; set objectives for maintenance and improvement of habitat, and quantify the amount and quality of habitats and population trends for the watershed.

Moose: Moose populations on the forest are stable, but habitat is declining, which will likely cause a decline in the population over time. Currently, ADF&G considers habitat on the Seward Ranger District to be of low quality and capable of supporting only about 2 moose per square mile. Density surveys conducted on the Kenai National Wildlife Refuge showed estimates of 10 moose/mi2 in high quality habitat produced by a wildfire in 1969 (U.S. Fish and Wildlife Service 1992). Without additional habitat disturbance to produce early successional stands, moose densities may decline to approximately 0.7 moose/mi 2 over the next 20 to 30 years (Howell 1990).

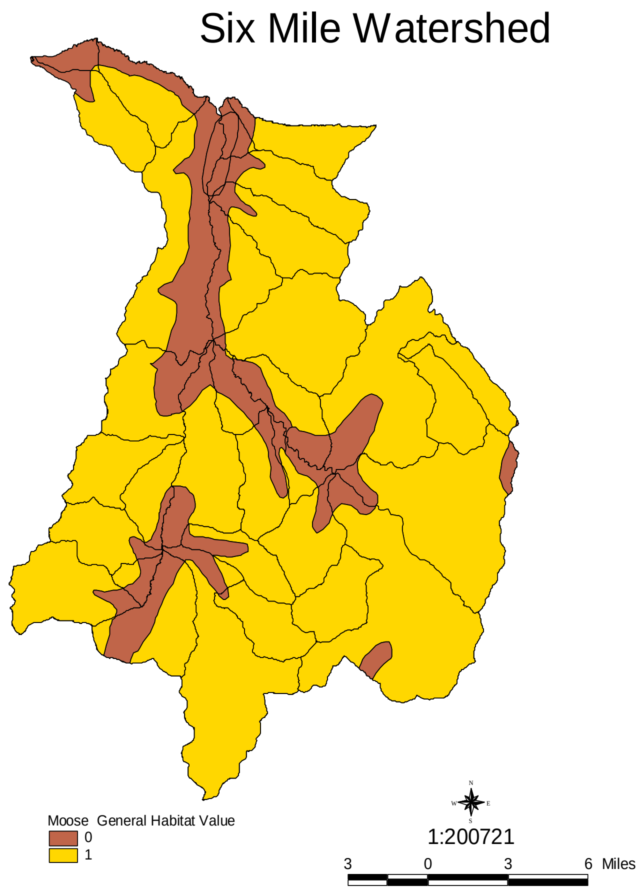
Moose are primarily associated with early-mid successional habitat and riparian areas. Winter range, or the available hardwood forage below 1000' elevation, is the primary factor limiting the moose population. Current winter range is along Six Mile Creek, East Fork of Six Mile Creek, Placer River near Turnagain Arm, and surrounding Hope (personal communication with Ted Spraker, ADFG). The juxtaposition of feeding and old growth hiding/thermal cover is also important, especially in areas of large-scale disturbance (Renecker and Schwartz 1998).

Bull Moose spend most of the summer in high elevations. w.shuster

During fall and winter, moose consume large quantities of willow, birch, and aspen twigs. Moose eat a variety of foods, particularly sedges, equisetum (horsetail), pondweeds, and grasses. During summer, moose feed on vegetation in shallow ponds, forbs, and the leaves of birch, willow, and aspen. Most moose make seasonal movements for calving, rutting, and wintering areas. They travel anywhere from only a few miles to as many as 60 miles during these transitions.

Hardwood regeneration occurs during stand initiation but only if mineral soil is exposed. Fire, flood and avalanche are the natural forces that typically expose mineral soil. Summer logging, scarification and prescribed fire can sometimes mimic these actions and generate hardwoods. In the absence of fire, winter range is limited to permanent shrub fields along flood plains, avalanche chutes, and riparian zones. Less than 3% of the area contains hardwoods or mixed hardwoods, which produce browse for moose. The current acres in the stand initiation development class are unknown in the watershed, since the data is 30 years old. Much of what was classified as early successional stages then can be in mid seral stages now, and new early stages have developed as a result of management, flooding, avalanches, fire, development, and logging.

Maintaining or increasing early successional stages in hardwoods and maintaining high quality riparian habitat can improve moose habitat. Prescribed fire and small timber sales can improve the amount and distribution of winter range (below 1000'), and in combination with selective thinning can create browse and promote growth of large trees and cover in adjacent areas.

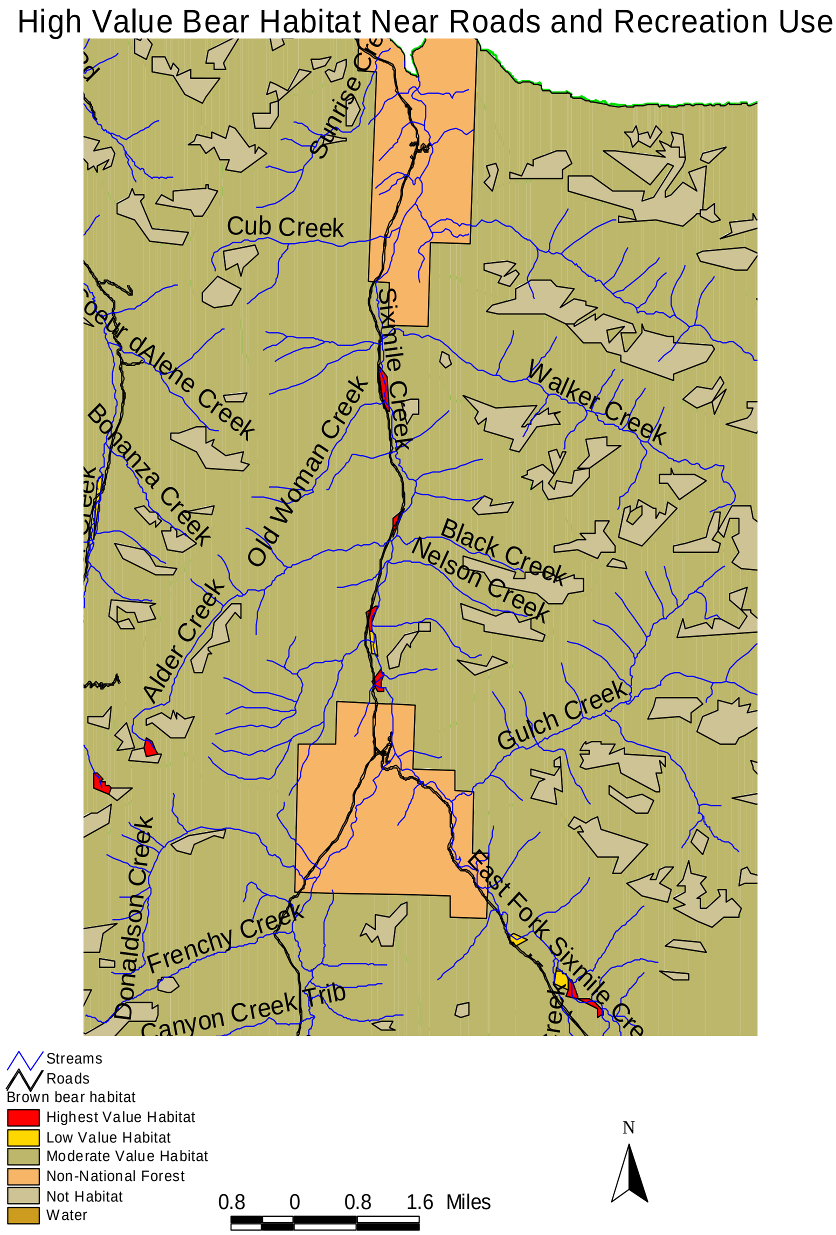


Map 3: Moose Habitat

The areas shown in brown are often used as rutting habitat or winter range.

Brown Bear: Brown bears are a wilderness species with large home range requirements and an intolerance of human disruption and development. The peninsula population is estimated at 280 bears, or 12 bears/1000km^2 (Suring et. al. 1998). The primary limiting factor for brown bears on the Kenai Peninsula is spring and summer feeding habitat. South facing hillsides and avalanche chutes, big game winter ranges, and salmon streams provide the high quality forage needed by bears before and after denning. The Six Mile drainage has small runs of silver and king salmon, limited moose winter range, and few south-facing avalanche chutes. Overall it provides low to moderate quality spring/summer feeding habitat, but may provide an important travel corridor for bears moving from the east side of the Kenai Peninsula into the Resurrection Valley and the Kenai National Wildlife Refuge. High value habitat occurs along Six Mile Creek, East Fork of Six Mile, Fresno Creek, and Tributaries of Bench Lake and Pass Creek. The watershed does not contain any brown bear core areas as identified in the forest plan.

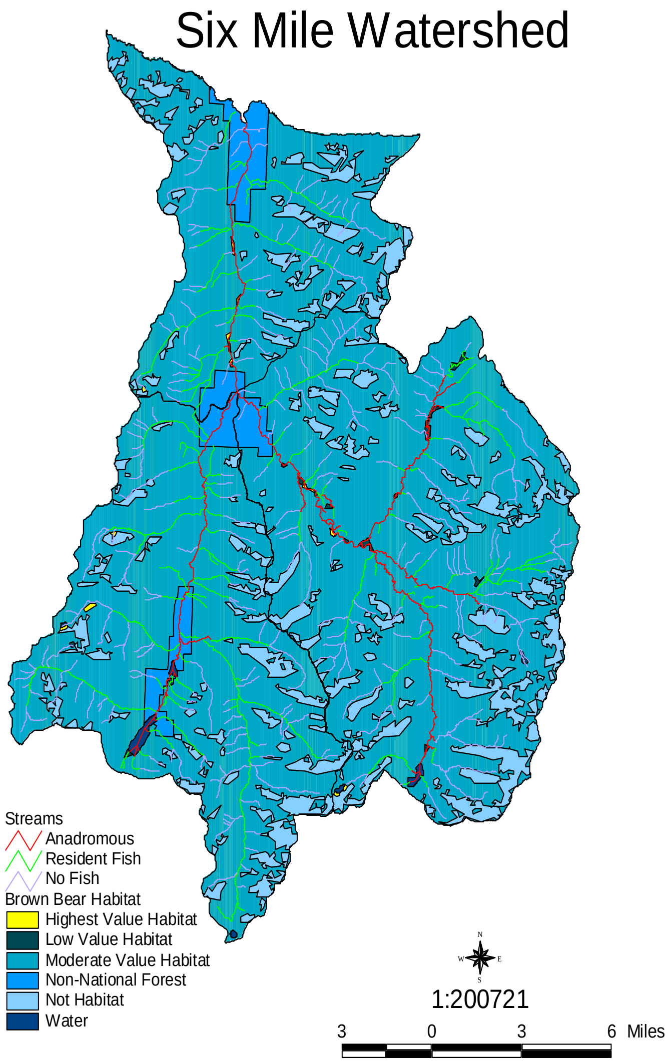
Areas with high potential for bear/human conflicts are high value habitat areas that are most accessible to people (near roads) such as near the confluence of Six Mile and Bear Creek, Six Mile and Old Woman Creek, East Fork of Six Mile and Silvertip Creek, and along Six Mile Creek near the Hope Wye. Areas of high recreation use near anadromous streams (Six Mile, East Fork, Gulch, Center, and Bench Creeks) are also potential conflict areas.



Map 4: High Value Bear Habitat near Roads and Recreation Use

Existing developments have reduced the historic habitat effectiveness by 86% (USFS 1996). Any additional developments that restrict access to salmon streams or inhibit movement through the watershed will negate the ability of the area to provide brown bear habitat.

Brown bear habitat can be maintained or improved by improving moose winter range, maintaining or improving riparian habitat quality, limiting development near salmon streams, reducing risk of bear human interactions through sensible recreation planning and public education. Provide buffers along anadromous fish streams to provide screened foraging habitat and managing human activity to minimize encounters. Identify important feeding areas in cooperation with the AK Fish and Game, and identify buffer zones as identified in the forest plan.



Map 6: Bear habitat

Table 3. Bear habitat Values

Habitat Value (Bear)	Acres
Highest Value Habitat	207
Low Value Habitat	391
Moderate Value Habitat	145226
Non-National Forest	7131
Not Habitat	22598
Water	470

Mountain Goat

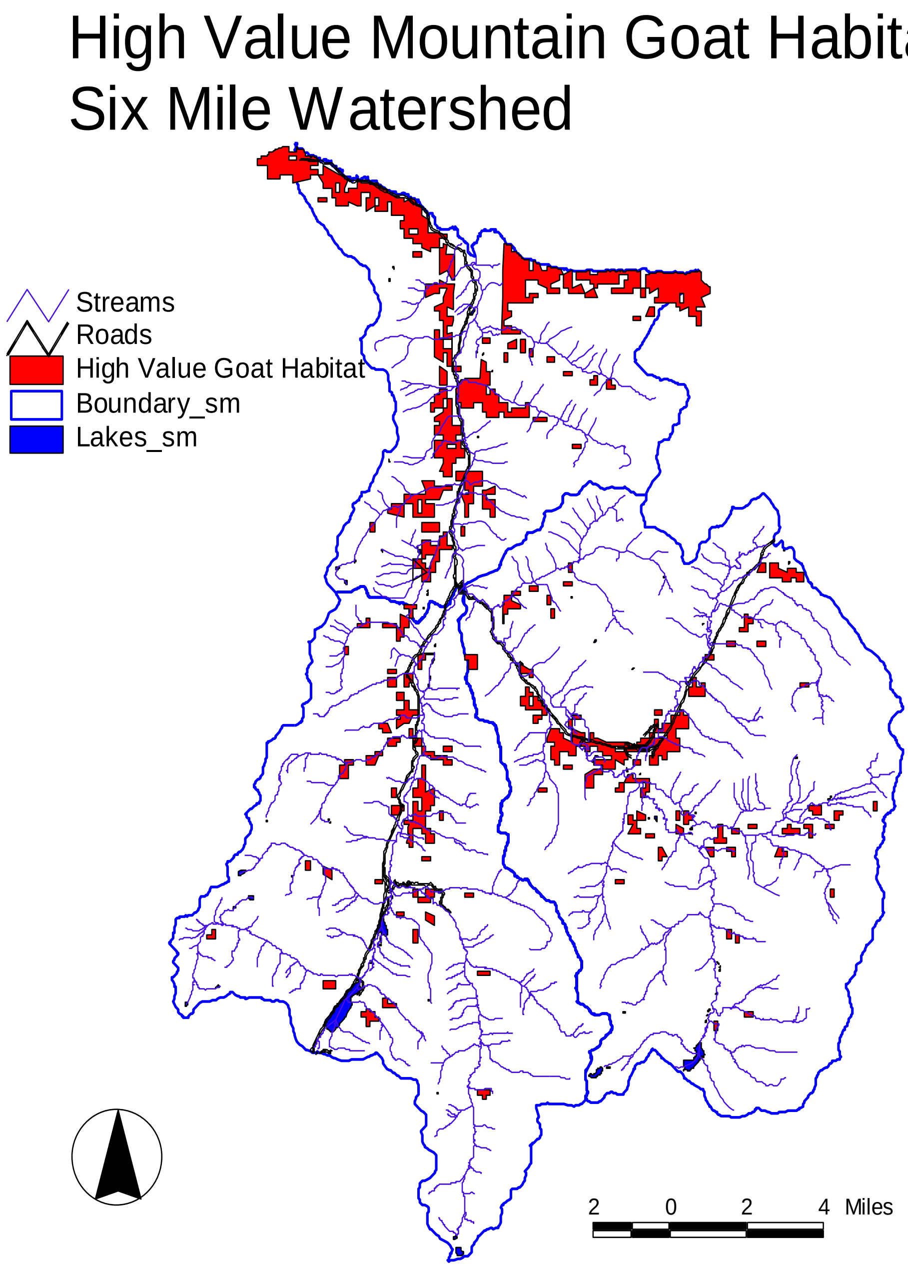
Mountain goat populations can be found from near sea level to over 10,000 feet. Mountain goats are both grazing and browsing animals, depending on the particular habitat and season of the year. They normally summer in high alpine meadows where they graze on grasses, herbs, and low-growing shrubs. Most goats migrate from alpine summer ranges to winter at or below tree line, but some may remain on windswept ridges. As winter advances and the more succulent plant species are frost-killed, the feeding habits shift to browsing. Hemlock is an important winter diet item, but feeding habits in winter are mainly a matter of availability (ADFG)

Mountain goats represent species using cliffs, alpine, sub alpine, and old-growth habitats. The quantity and quality of the winter habitat is thought to be the most limiting factor for mountain goats in South-central Alaska. Mountain goats use old-growth forest habitat with trees having large dense crowns for winter shelter and as a foraging area. Mountain goats are usually found near escape cover, steep cliffs with slopes over 50 degrees. Forested habitat within one-quarter mile is highest value and value decreases out to one-half mile (USDA 2002).

Mountain goats are sensitive to habitat change, disturbance and hunting pressure (Chadwick 1973). Use of steep alpine cliffs and rocky areas makes them particularly vulnerable to aircraft over flights during critical life periods, winter range and kidding season. Habitat value for mountain goats is reduced by human disturbance and development (Suring et al. 1998). Developments near winter range will have long-term effects on individuals or herds. Aircraft over flights are a short-term limited duration activity (USDA 2002).

The highest value habitat for mountain goats occurs adjacent to Turnagain Arm, on the slopes west of Six Mile Creek, some slopes south of East Fork of Six Mile, Falls Creek, Walker Creek, Gulch Creek and Nelson Creek. The greatest number of goats (130) were counted by AKFG in 2002 in the area surrounded by Six Mile, East Fork, Granite Creeks and Turnagain Arm (personal communication with Ted Spraker, AKFG).

Winter habitat can be maintained or improved by retaining or promoting old growth habitat and hemlock, especially near steep alpine cliffs and rocky areas, and restricting aircraft over flights to keep them short term and limited in duration.



Map 7: Goat Habitat

<u>Species of Special Interest</u>

Species of Special Interest are the gray wolf, lynx, marbled murrelet, river otter, Townsend's warbler, wolverine, bald eagle, northern goshawk and osprey.

Gray wolf

Wolves are highly social animals and usually live in packs that include parents and pups of the year. Although pack size usually ranges from 2 to 12 animals, packs of as many as 20 to 30 wolves sometimes occur. The average size pack is 6 or 7 animals. There are approximately 10-11 packs on the Seward District, 1 (possibly 2) of these occur in the Six Mile Watershed. One pack occurs centered around Six Mile Creek, East Fork, and Granite Creek (Silvertip Pack), and another pack may exist in Resurrection Creek.

In most areas wolf packs tend to remain within a territory used almost exclusively by pack members, with only occasional overlap in the ranges of neighboring packs. In Alaska the territory of a pack often includes from 300 to 1,000 square miles of habitat with the average being about 600 square miles. Wolves normally breed in February and March, and litters averaging about five pups are born in May or early June. Pups are usually born in a den excavated as much as 10 feet into well-drained soil, and most adult wolves center their activities around dens while traveling as far as 20 miles away in search of food, which is regularly brought back to the den. Wolves are great travelers, and packs often travel 10 to 30 or more miles in a day during winter. Dispersing wolves have been known to move from 100 to 700 miles from their original range.

In spite of a generally high birth rate, wolves rarely become abundant because mortality is high. In much of Alaska, hunting and trapping are the major sources of mortality, although diseases, malnutrition, accidents, and particularly intraspecific strife act to regulate wolf numbers. Wolves are carnivores, and in most of mainland Alaska moose and/or caribou are their primary food, with Dall sheep being important in limited areas. On the Kenai Peninsula, all the wolves have lice. Habitat is fair, and could be improved by improving moose habitat (personal communication with Ted Spraker, AKFG).

Maintaining abundant populations of prey species, controlling access on new roads and working with ADFG to reduce or eliminate illegal harvest are the primary methods for maintaining healthy populations in the Six Mile Watershed.

Lynx.

Lynx inhabit much of Alaska's forested terrain and use a variety of habitats, including spruce and hardwood forests, and both sub alpine and successional communities. The best habitat occurs where there is a diversity of vegetation types with an abundance of early successional growth, which provides habitat for snowshoe hare and other small prey species. Hares also like dense conifer thickets of seedlings and saplings for food and cover. Mating occurs in March and early April and kittens are born about 63 days later under a natural shelter such as a wind fallen spruce, a rock ledge, or a logjam. The production and survival of lynx kittens is influenced dramatically by cyclic changes in snowshoe hare and other small game populations. Roads may also affect populations by increasing the vulnerability of lynx to hunters and trappers. Current populations are believed to be below historical high levels.

In Six Mile watershed, maintaining or promoting early stages of spruce and hardwood forests and vegetative diversity will promote or maintain lynx habitat.

Marbled Murrelet

Marbled Murrelets are medium sized seabirds that inhabit near-shore coastal waters, inland freshwater lakes, and nest in inland areas of old-growth conifer forest or on the ground (Carter and Sealy 1986, Marshall 1988). They are usually found within 5 miles of shore. Except for the fall period when they are molting, flightless, and stay on the ocean, murrelets are known to fly to tree stands throughout the year.

Throughout much of its range in the Pacific Northwest, British Columbia, and Alaska, the marbled murrelet nests in large, mature coniferous trees within stands of structurally complex, coastal old-growth forest. Data from forested areas elsewhere within their range indicate that high volume stands of old-growth conifer forests in relatively close proximity to the coast are essential nesting habitat.

Population trends within the Chugach National Forest are generally downward for the long-term, with a 67 percent decline since surveys were done in 1972 and 1973, but have been stable since 1990 (Kuletz 1997). Possible causes of estimated overall Alaska declines are oil spills, mortality from gill netting, cyclic changes in marine food productivity, and the harvesting of productive old-growth forests (which are likely their primary nesting habitat)

Surveys for marbled murrelets were conducted at inland sites on the Chugach National Forest. Kenai Peninsula in 1991, 1994, and 1995 (TJSDA For. Serv., unpubl. data). Number of detections ranged from 23 in 1994 to 101 in 1991 documenting the presence of this bird on this portion of the Chugach National Forest. Potential nesting habitat for Marbled murrelets may exist in the Six Mile Watershed.

Old growth habitat, which could serve as potential nesting habitat in the Six Mile watershed is being lost due to the impacts of the spruce bark beetle. Old growth habitat that is not infected, especially within 5 miles of the coast, should be maintained, and old growth characteristics such as large trees and structurally complexity could be promoted through thinning in mature stands to enhance or create nesting habitat. The best potential nesting habitat occurs within 0.5 miles of the coast, within 0.5 miles of Six Mile Creek, and some areas adjacent to Palmer Creek.

River Otter

River otters are associated with coastal and fresh water environments and the immediately adjacent (within 100-500 feet) upland habitats. Beach characteristics affect the availability of food and cover, and adjacent upland vegetation also provides cover. Old-growth forests have the highest habitat value, providing canopy cover, large-diameter trees and snags, and burrow and den sites. Younger successional stages provide lower quality habitat.

River otters in Alaska hunt on land and in fresh and salt water. They eat snails, mussels, clams, sea urchins, insects, crabs, shrimp, octopi, frogs, a variety of fish, and occasionally birds, mammals, and vegetable matter.

They travel several miles overland between bodies of water and develop well-defined trails that are used year after year. A family unit is made up of a female and her pups, with or without an adult male. The family usually travels over an area of only a few square miles.

River otters have no significant predators except man. There is some concern that developed recreation may impact their populations.

In the Six Mile watershed, due to the increasing losses of old growth habitat from the spruce bark beetle, high quality habitat for otters may be declining. Efforts to promote or maintain mature or old growth trees, canopy cover, and snags adjacent to coastal and fresh water environments will help maintain otter populations.

Townsend’s warbler

Townsend's warblers are fairly common breeding birds on the Chugach National Forest. In the fall, Townsend's warblers may depart interior Alaska by late August.

Townsend's warblers can be found primarily in coniferous forests or mixed forests where coniferous trees comprise a predominant feature of the habitats (Bent 1953, Erskine 1977).

In central Alaska, Townsend's warblers were the most abundant breeding birds in white spruce dominated mature forests (Spindler and Kessel 1980). They also occurred in mixed coniferous-deciduous forests. On the Kenai Peninsula, Townsend's warblers were the most abundant breeding bird in 50- and 100-year old stands (Quinlan 1979).

Studies in Southeast Alaska suggest a preference for older conifer forest. On the Kenai Peninsula, Quinlan (1979) reported that densities of Townsend's warblers in 30-year-old white spruce forest plots were less than half that found in 50- to 100-year-old white spruce forests.

At present little information on population trends in Canada or Alaska is available (Wright et al. 1998).

Mature and old growth habitat is being lost due to the impacts of the spruce bark beetle. Old growth habitat that is not infected should be maintained, and old growth characteristics such as large trees and structurally complexity could be promoted through thinning in mature stands to enhance or create potential habitat.

Wolverine

The wolverine is an animal of montane forest, tundra, and taiga. Several factors appear to influence wolverine habitat selection at the landscape and stand levels. The distribution and density of large mammal carrion is a primary factor along with the level of human disturbance. Other habitat parameters such as escape cover from predators, availability of den sites, prey concentrations, and cover can affect daily movement and habitat use patterns (Howell 1999).

Wolverine in Idaho showed a significant preference for high elevation, rocky habitats in summer and montane conifer communities in winter. Females showed a specific preference for den sites and talus slopes, which were neither widely available nor evenly distributed across the landscape (Copeland 1996). Wolverines do not appear to avoid habitats inhabited by other predators, or areas with large openings.

The wolverine is primarily a scavenger, found in the wilder and more remote areas of Alaska. They have tremendous physical endurance and can travel up to 40 miles a day in search of food. The breeding season extends from May through August. The abundance of food determines whether a pregnancy will be maintained (delayed implantation) and the number of young that will be born. Wolverine litters are born between January and April. In Interior and northern Alaska most young are born in snow caves. These caves usually consist of one or two tunnels that can be up to 60 yards long. Wolverines travel extensively in search of food. Home range sizes are vast, with adult males using areas up to 240 square miles. Adult females use smaller home ranges encompassing between 50 to 100 square miles.

The primary natural mortality factors are starvation and being killed by other predators, primarily wolves. However, most wolverine mortality is due to trapping by humans. Human settlement and disturbance may have been a primary factor in the extirpation the wolverine from much other historic range (Wilson 1987). As a general rule, management actions that increase human access into remote areas, decrease the amount or distribution of carrion available, or disrupt sensitive areas such as denning habitat or dispersal corridors will decrease the effectiveness of wolverine habitat (Banci 1994).

A winter track survey done in 1995 in the Resurrection Pass was used to estimate wolverine density on the Kenai Peninsula (Golden 1996). In 1992 aerial track surveys of the Kenai Peninsula showed track concentrations along Six Mile and Canyon Creeks. Wolverine density on the Kenai Peninsula was estimated at that time to be 5.2 wolverine/1000km^2. Wolverines are commonly trapped on the Kenai Peninsula, and the harvest rate has declined only slightly since 1980. Trapping harvest on the Kenai Peninsula is probably a significant source of mortality for the population. The Forest Plan states that three land management issues affect the long-term health and persistence of wolverine populations: a consistent and diverse source of large animal carrion, the presence of refugia from human disturbance, and an evaluation of management actions at the landscape level.

In the Six Mile watershed, maintaining habitat for large animals such as moose, sheep, goats, and caribou, and identifying and reducing human disturbance to potential denning sites will be important to maintaining populations.

Bald Eagle

Bald Eagles are more abundant in Alaska than anywhere else in the United States. Bald Eagles are often found along Alaska's coast, offshore islands, and Interior lakes and rivers. Most Bald Eagles winter in southern Alaska, but some leave the state during cold months. Bald Eagles often use and rebuild the same nest each year. Nest trees are usually close to water, afford a clear view of the surrounding area, and often provide sparse cover above the nest. Eagles in South-central Alaska nest in old cottonwood trees near water. Nest building begins in April. In late April, two-three eggs are laid several days apart. Incubation lasts about 35 days. When the young hatch, sibling rivalry is common and the weaker, usually the younger, chick is killed or starved. The surviving young leave the nest after approximately 75 days. Bald Eagles congregate where food is plentiful, and they may continue to roost near the nest tree.

Pesticides in the eagles' prey can affect reproductive success. Alaska Bald Eagles seem to be reproductively healthy, but contaminants have been recorded in Alaska fish populations and in Bald Eagles. A greater threat to Alaska's Bald Eagle population is destruction of their nesting habitat by logging and nest disturbances. Nest trees tend to be the largest in the stand and are usually 400 years old. Fish are the main diet of the Bald Eagle. Herring, flounder, Pollock, and salmon are taken along the coast, while the Interior populations prey heavily upon salmon. Eagles also prey upon waterfowl, small mammals, sea urchins, clams, crabs, and carrion.

Approximately eight nests within four or five territories are known to exist in the watershed. Most nests occur along the coast of Turnagain arm.

Bald eagle nest protection standards are outlined in an Interagency Agreement with the U.S. Fish and Wildlife Service. There is a 330-foot retention zone around known eagle nest locations. There are also blasting, road construction, and over flight restrictions. The active bald eagle nesting season is generally from March 1 to August 31.

Habitat management in the Six Mile watershed should focus on retaining large old cottonwoods for nesting habitat, promoting future nesting habitat, and reducing disturbance near nest trees.

Northern Goshawk

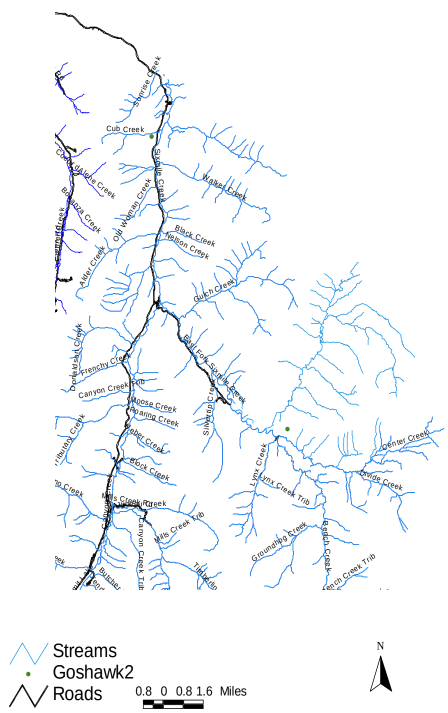
The northern goshawk is a low density, forest raptor that feeds in the under story on squirrels, birds and snowshoe hares. The amount and juxtaposition of feeding and nesting habitat appears to be the primary limiting factors (Iverson et. al. 1996). Thirteen of 17 known goshawk nests on the SRD are in old growth hemlock-spruce stands characterized by a closed canopy, large average diameter, gap regeneration and an open under story. The Cub Creek nest territory has been active since its discovery in 1995 and has 3 alternate nest sites. An aggressive pair was reported from the Bear Creek Road in 2000 near old growth stands 31 and 33.

Ten old growth stand totaling less than 500 acres were mapped in the Hope Highway project area. The Bear Creek old growth complex (Units 25,31,33) totals only 64 acres but functionally may be part of a larger old growth complex in the area. The Cub Creek old growth complex (Units 120,121,138) that shelters the active territory totals 222 acres. The remaining stands (Units 49, 321,256) range in size from 13-77 acres and appears to be too small and isolated from other old growth to function as nesting habitat. The remaining old growth areas in the watershed are unknown at this time. Many of the areas of mature and potential old growth stands which can be identified on the GIS map layers may be dead due to the spruce bark beetle or inaccurate.

The spruce bark beetle infestation is accelerating the rate at which spruce disappear from old growth stands. Gap regeneration is taking place, but most gaps are too small to allow for spruce regeneration. Since spruce typically make up less than 25% of the stand and are well distributed, this should not impact the structure of nesting habitat. The function of these stands will be impacted by reducing the long-term conifer diversity and therefore the prey diversity and density.

Two goshawk territories are known to occur within the watershed. The Cub Creek territory has three nests lie in the project area. Incomplete active/inactive data available 1995 through 2001. The nests (all hemlock) were not active in 2002. One nest was mostly destroyed in 2000. The Cub Creek territory lies in a mature hemlock-spruce stand. Another territory occurs on the Glacier District off East Fork of Six Mile between Center and Granite Creeks.

Goshawk Nests



Map 8: Goshawk Nests

Mature and old growth habitat is being lost due to the impacts of the spruce bark beetle. Old growth habitat that is not infected should be maintained, and old growth characteristics such as large trees and structural complexity could be promoted through thinning in mature stands to enhance or create potential habitat. Some nesting habitat

can be promoted in mature hemlock stands by thinning to reduce competition, increase growth, and open the under story, while retaining denser canopies. This may help replace losses of some nesting habitat in mature spruce due to the bark beetle.

Osprey

The osprey's diet is mainly fish. Ospreys are migratory and spend their winters in Mexico and Central and South America. Ospreys return to Alaska in late April. A breeding pair probably mates for life and returns to the same nest area each year. The nest is situated near water, atop trees, posts, rock pinnacles, or even the ground. Little is known about the status of osprey populations in Alaska. They frequently adapt to human activities, but any disturbances, which keep adults from their nests in May or June, may cause the eggs or young nestlings to become chilled and die. The osprey is adversely affected by steam or waterway alterations, specifically those that reduce fish populations or visibility in areas traditionally used as feeding areas. Osprey are highly susceptible to egg thinning by pesticide contamination.

Management in the Six Mile watershed should include maintenance of healthy riparian areas, and nest searches in areas of any reported osprey sightings, with protection of any discovered nest sights as identified in the Forest plan.

D. Wildlife Habitat: Vegetative Composition and Structure

The vegetation composition and structure plays a critical role in providing wildlife habitat and maintaining viable populations of all species on the forest (See Tables 3 and 4). Diversity is the key component, with a desired condition of a fairly even distribution of age classes in each vegetation type. A diversity of vegetation types within the natural range of variability is also desirable.

Table 4. Habitats Associated with these species of interest.

General Habitat Type	Kenai Peninsula
Early forest succession	Moose
	Lynx
Late forest succession	Townsend's warbler
	Marbled Murrelet
	Northern goshawk
Alpine	Mountain goat
Freshwater	Brown bear
	Wolverine
Riparian	Bald eagle
	Brown Bear
	Moose
	Osprey
	River otter
	Townsend's warbler
	Wolverine

Table 5. Relative importance of the general habitat types to TES, MIS, and SSI.

	Forested	Scrub	*Herb-Gram-Moss-Lich	Sparsely Vegetated	Tidal Estuarine	Freshwater	*Alpine	Riparian
Percent of Watershed Acres	25%	14%	35% (alpine)	18% rock	0	1%	35%	Hi
BROWN BEAR	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Hi
MOOSE	Hi	Hi	Mod			Mod		Hi
MOUNTAIN GOAT	Hi		Mod	Mod			Hi	

GRAY WOLF	Mod	Mod	Mod			Mod	Mod	Hi
LYNX	Hi					Mod	Mod	
MARBLED MURRELET	Hi			Low				
RIVER OTTER	Mod	Mod	Mod		Hi	Hi		Hi
TOWNSEND'S WARBLER	Hi	Mod						Hi
WOLVERINE	Mod	Low	Low	Mod	Low	Hi	Mod	Hi
BALD EAGLE	Hi		Mod		Hi	Mod		Hi
NORTHERN GOSHAWK	Hi	Low				Low		Low
OSPREY	Mod				Hi	Mod		Hi
TRUMPETER SWAN					Hi	Hi		

*Note (grass and alpine are combined in this table and the percentage is shown under both columns.

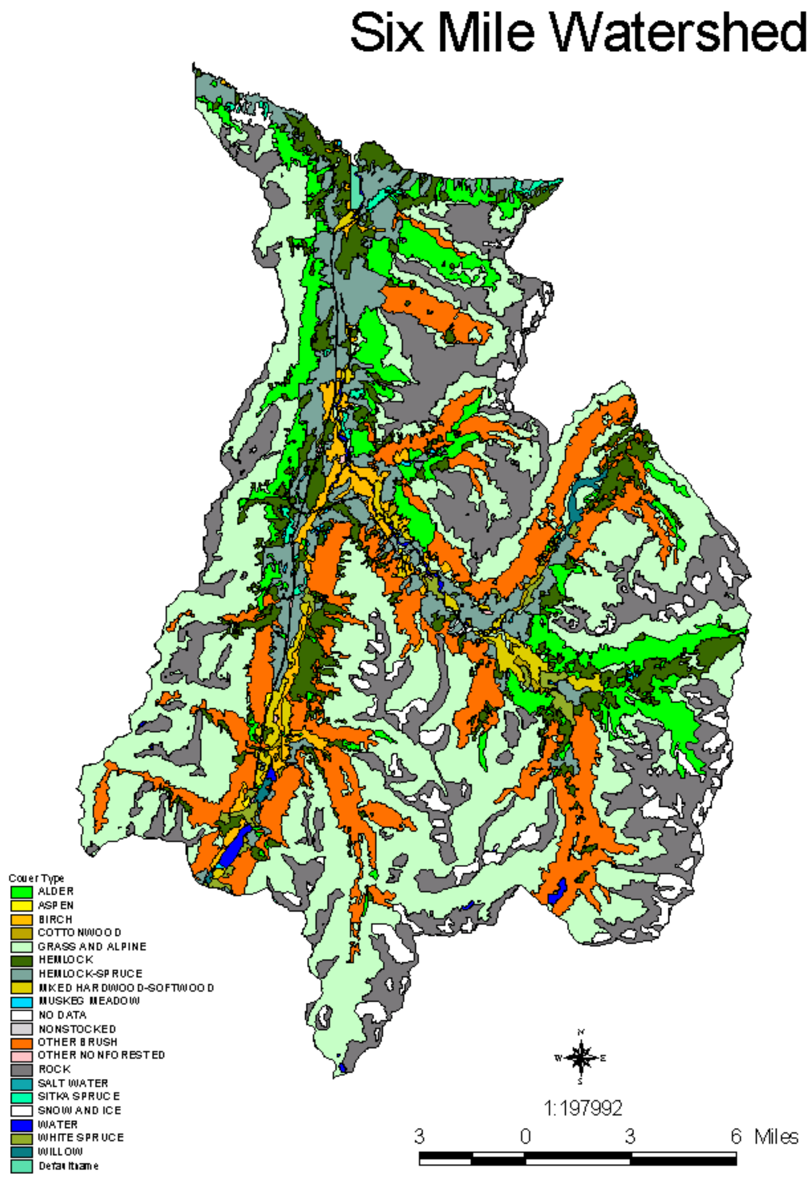
The GID cover type layer shows the majority of the habitat (67%) in the watershed is grass and alpine (35%), rock (18%), and brush (14%) (See Table 5 and Map 9). This provides Low-Moderate quality habitat for brown bears, gray wolves, moose, lynx, wolverine, and Peale's peregrine, and high value habitat for mountain goats. Forested habitats, which are limited to 26% of the watershed, provide the highest quality habitat for the majority of management indicator and species of special interest. Ice and snow make up 4% of the watershed, and although it is not listed in table provides some foraging habitat for species like wolverines, and travel corridors for bears and wolverines, wolves and an occasional moose.

Table 6 – All Cover Types	**Category**	**Acres**	**Percent**
GRASS AND ALPINE	Non Forested	62,451	35
ROCK	Non Forested	31,462	18
OTHER BRUSH	Non Forested	24,838	14
ALDER	Non Forested	14,129	8
HEMLOCK-SPRUCE	Forested	13,060	7
HEMLOCK	Forested	12,706	7
SNOW AND ICE	Non Forested	6,770	4
BIRCH	Forested	3,202	2
MIXED HARDWOOD-SOFTWOOD	Forested	2,388	1
WHITE SPRUCE	Forested	1,335	1
WATER	Non Forested	915	1
SITKA SPRUCE	Forested	655	0
COTTONWOOD	Forested	578	0
WILLOW	Non Forested	532	0
OTHER NON FORESTED	Non Forested	491	0

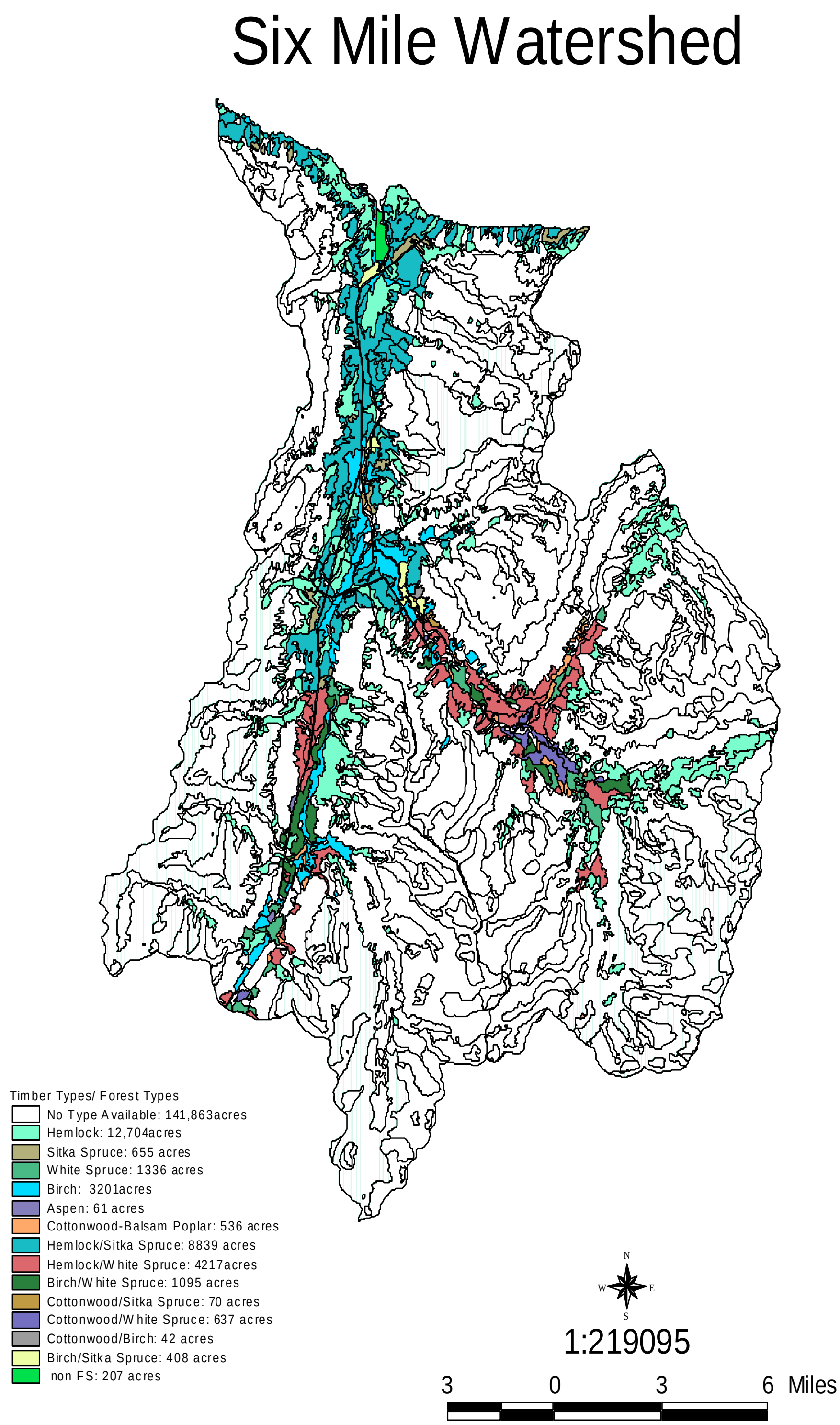
MUSKEG MEADOW	Non Forested	241	0
NON NATIONAL FOREST LAND	Non Forested	207	0
ASPEN	Forested	61	0
NONSTOCKED	Non Forested	5	0
		176,026	100

The GIS timber type layer also displays the vegetation type as well as the stand classes or vegetative structure (See Map 10, 11 and Table 8).

The existing vegetative structural data is 30 years old, and gives an idea of conditions that existed during that time. The majority of the forested acres were in the pole timber size class, and likely the stem exclusion stage. At this point in time, much of this may now be in the saw timber class and under story Reinitiation phase. The seedling sapling phase, which is critical to moose for browse in the hardwood vegetation types, would now be in the pole timber size class. It is unknown how much currently exists in the seedling/sapling stage. Old growth would not have changed much in this time frame. It is likely that there is currently limited acres in the early and late successional stages, and an over abundance in under story Reinitiation. The Hope Highway Environmental Analysis, which covers a large portion of the Six mile Watershed, showed similar conditions, based on recent data (see Table 10).

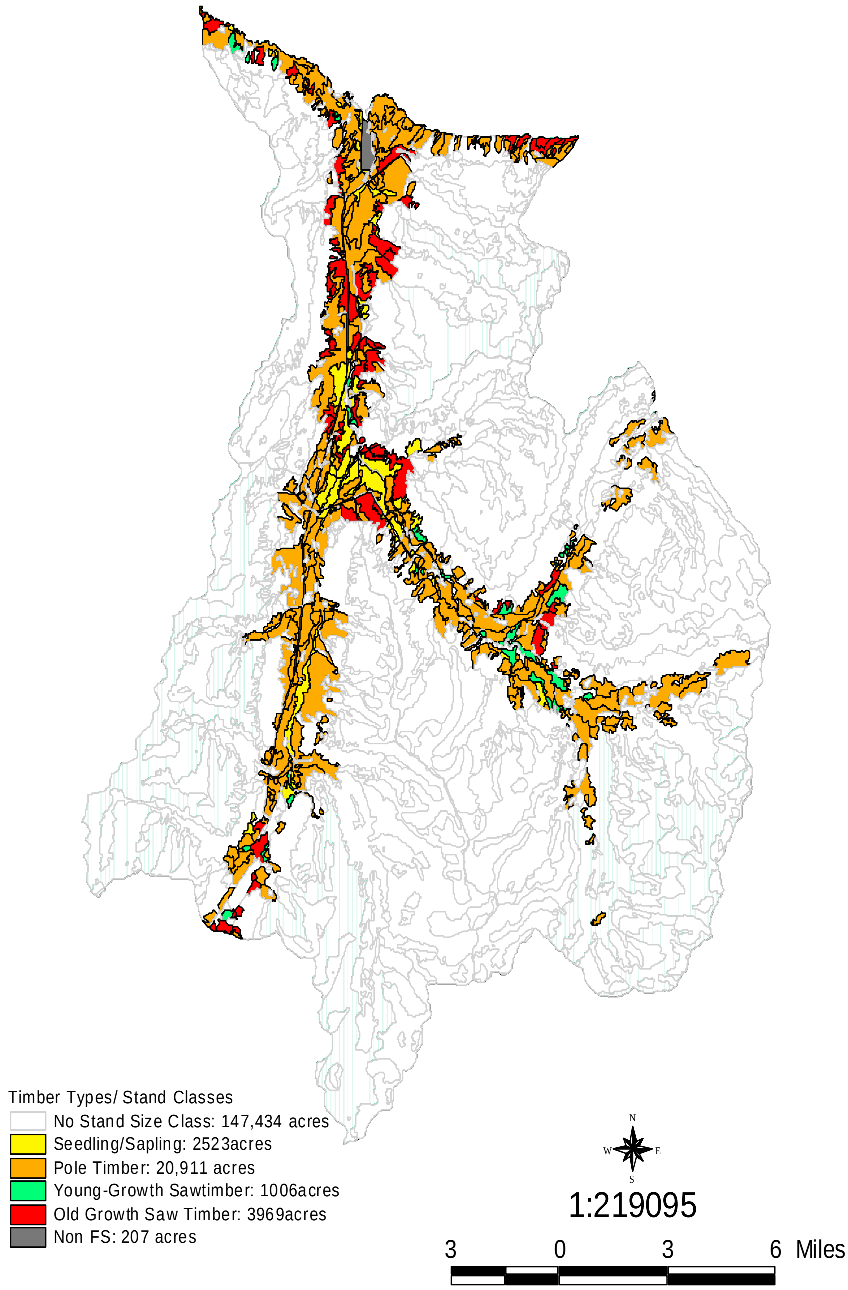


Map 9: Cover Types



Map 10: Timber Types

Six Mile Watershed



Map 11: Stand Classes

The forest timber type GIS layer shows only 19% of the watershed is forested.

Table 8 - Size and Stand Development Class by Species

Species	Stand Size Class	Stand Development Class	Acres	Percent by Species	Percent Total Landscape
Non Forested			141,863	100	81
Hemlock	Not Classified		5,090	40	3
	Seedling/Sapling	Stand Initiation	235	2	0
	Pole Timber	Stem Exclusion	7,379	58	4
Total			12,704	100	7
Sitka Spruce	Not Classified		256	39	0
	Seedling/Sapling	Stand Initiation	16	2	0
	Pole Timber	Stem Exclusion	20	3	0
	Saw Timber	Under story Reinitiation	37	6	0
	Old Growth Saw Timber	Old Growth	326	50	0
Total			655	100	0
White Spruce	Not Classified		190	14	0
	Seedling/Sapling	Stand Initiation	89	7	0
	Pole Timber	Stem Exclusion	674	50	0
	Saw Timber	Under story Reinitiation	34	3	0
	Old Growth Saw Timber	Old Growth	349	26	0
Total			1,336	100	1

Birch	Not Classified		23	1	0
	Seedling/Sapling	Stand Initiation	2,177	68	1
	Pole Timber	Stem Exclusion	1,001	31	1
Total			3,201	100	2
Aspen	Seedling/Sapling	Stand Initiation	6	10	0
	Pole Timber	Stem Exclusion	55	90	0
Total			61	100	0
Cottonwood	Not Classified		12	2	0
	Pole Timber	Stem Exclusion	132	25	0
	Saw Timber	Under story Reinitiation	297	55	0
	Old Growth Saw Timber	Old Growth	95	18	0
Total			536	100	0
Hemlock-Sitka Spruce	Pole Timber	Stem Exclusion	5,819	66	3
	Saw Timber	Under story Reinitiation	85	1	0
	Old Growth Saw Timber	Old Growth	2,935	33	2
Total			8,839	100	5
Hemlock-White Spruce	Pole Timber	Stem Exclusion	3,809	90	2
	Saw Timber	Under story Reinitiation	145	3	0
	Old Growth Saw Timber	Old Growth	263	6	0
Total			4,217	100	2
Birch-White Spruce	Not Classified		1,274	100	1

Cottonwood-Sitka Spruce	Saw Timber	Under story Reinitiation	70	11	0
	Pole Timber	Stem Exclusion	298	47	0
	Saw Timber	Under story Reinitiation	338	53	0
	Old Growth Saw Timber	Old Growth	1	0	0
Total			637	100	0
Cottonwood-Birch	Pole Timber	Stem Exclusion	42	100	0
Birch-Sitka Spruce	Not Classified		408	100	0
No Data			207	100	0
Grand Total			176,050		100

Table 9 – Stand Structure

Forested Stand Size Class	**Stand Development Stage**	**Acres**	**Percent of Forested Acres**
Not Classified		7,460	22
Seedling/Sapling (5”-9” dbh)	Stand Initiation	2,523	7
Pole Timber (9” – 15” dbh)	Stem Exclusion	19,229	56
Saw Timber (15” - 25” dbh)	Under story Reinitiation	1,006	3
Old Growth Saw Timber (>25” dbh)	Old Growth	3,969	12
Total		34,187	100

All Stand Size Classes	**Stand Development Stage**	**Acres**	**Percent of Total Acres in Assessment Area**
Non Forested		141,86	81

		3	
Not Classified		7,460	4
Seedling/Sapling (5”-9” dbh)	Stand Initiation	2,523	1
Pole Timber (9” – 15” dbh)	Stem Exclusion	19,229	11
Saw Timber (15” - 25” dbh)	Under story Reinitiation	1,006	1
Old Growth Saw Timber (>25” dbh)	Old Growth	3,969	2
Total		176,050	100

Table 10. Stand Development Classes for the Hope Highway Project Area

Stand Development Class	Desired %	Existing % Hope Highway
Stand Initiation	25	10
Stem Exclusion	25	33
Stand Reinitiation	25	50
Old Growth	25	7

Management Direction

The Forest Plan identifies the following management direction for the watershed, and directs how different areas will be managed for habitat, wildlife, and other uses which may impact wildlife.

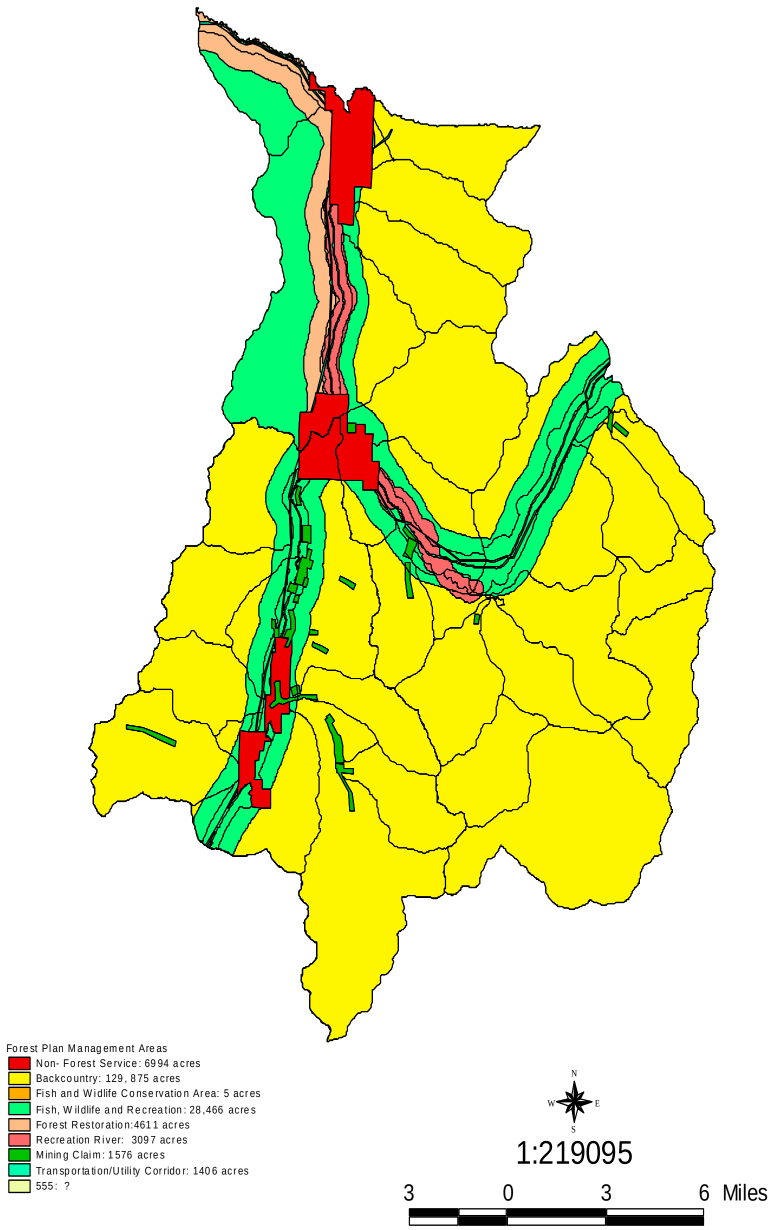
Table 11: Management Area Prescriptions

Management Area Prescription	Acres	Percent
Backcountry	129875	74
Fish, Wildlife, Recreation	28466	16
Non Forest Service Lands	6994	4
Forest Restoration	4611	3

Recreation River	3097	2
Mining Claim	1576	1
Transportation/Utility Corridor	1406	1
Salt Water	16	0
Fish and Wildlife Conservation	5	0
Total	176046	100

The backcountry prescription, which dominates the area, calls for vegetation in the late sucessional stages unless regenerated by resource projects. New roads are not allowed, reducing impacts to wildlife. Most of the accessible areas by road are in the Fish, Wildlife, and Recreation prescription. Management here should emphasize maintaining genetic diversity for wildlife, and enhancing watch-able wildlife, hunting and subsistence opportunities. These areas are very suitable for moose habitat enhancement projects, with consideration for reducing moose/vehicle collisions. Wildlife habitat improvement projects are allowed in all management areas.

Six Mile Watershed



Map 12: Management Areas

Appendix A: Index of Available Wildlife Information:

Breeding Birds

Breeding bird survey folders available at KLWC in the wildlife files contain bird-sighting data from 1983 through 2000 (not every year). Of all the BBS routes, only the Hope route (#216) lies partially within the project area. Of that route, only stations 30 through 50 (approx.) apply directly.

Neotropical bird survey folders also available at KLWC. The Cripple Creek folder applies to an area outside the project area, but close to and comparable to the project area. It contains sighting data from 1994 through 2001 (not every year). Approximately 8 to 15 different species sighted with no trend apparent.

Document entitled "Bird Densities in Chugach National Forest, Alaska as Determined by the Variable Circular Plot Method" available at Seward Ranger Station in wildlife file cabinet in folder labeled "Historic WL Surveys". In 1984, an FS crew ran six transects, one of which fell in the Sunrise area, Table 1 gives densities per hectare of 16 bird species. Table 2 gives confidence intervals for the density estimates.

Goshawk

Goshawk monitoring folders available at KLWC. Of the several known nests on SRD, only the three Cub Creek nests lie in the watershed. Incomplete active/inactive data available 1995 through 2001. Descriptions of nest trees available (all hemlock). One nest mostly destroyed in 2000. The Cub Creek territory lies in a mature hemlock-spruce stand. Most goshawk monitoring on the SRD has occurred in the Resurrection and Six Mile drainages.

Bald Eagle

Bald eagle nesting survey folders available at KLWC. Incomplete data available from 1983 to 1991. Less incomplete data available 1991 through 2001. Data include winter sightings, nest descriptions and locations and active/inactive categorizations. Approximately eight nests within three or four territories known to exist in project area. Anecdotal accounts suggest more.

Owl

Owl nesting survey folders available at KLWC. Incomplete data available 1993 through 2001. Of the four or five owl survey routes on SRD, only the Hope route lies partially in the project area. On that route, only stations 12 through 22 (approx.)

apply. Data include species of owl heard, time, weather, bearing and distance to owl(s), date and weather. Owl species heard in the project area include northern saw whet, boreal, great horned and great gray.

Document entitled " Owl Surveys on the Kenai Peninsula and Afognak Island, Chugach National Forest Spring 1980" available at KLWC. Field procedures and data available similar to more recent owl surveys. Data from the Kenai Peninsula include the Hope Highway, which lies, in part, within the project area. Document includes conclusions about effect of weather and time of day on results. Results suggest that wind and rain correlate with reduced owl vocalization and reduced effectiveness of the survey protocol.

Moose
Document entitled "Evaluating Moose Winter Range and Utilization on Six Prescribed Burn Units At the Chugach National Forest, Alaska" available at Seward Ranger Station in wildlife file cabinet in folder labeled "Browse Utilization FY 83-84 Reports". The East Fork 3 unit (47 ac., burned 1978) lies in the project area. Document lists 34%, 20% and 9% as utilization for birch, willow and aspen respectively. Document also reports range condition as progressive for these three species and lists twigs/ac as 6,500, 140,400 and 6,300 again for birch, willow and aspen respectively.

Memorandum to files dated February 24,1964 available at Seward Ranger Station in wildlife file cabinet in folder labeled "Moose Winter Range Survey, 1964". Personnel flew the entire Six Mile drainage in February of 1964 and counted 96 moose. They estimated seeing only 75% of moose present.

Several folders labeled East Fork Creek (various numbers) available in the wildlife burn unit file cabinets at SRD. Partial browse utilization surveys done in East Fork 3 unit in 1983, 1990 and 1994. East Fork 3 shows increase in utilization by moose generally for the four browse species measured. Other units did not have more than one utilization survey completed, therefore no trend apparent. East Fork 21 showed 10 moose-use days in winter 1993-94. East Fork 8 shows 68% use of willow in 1990, 12 years after burning.

Master's thesis of T.V. Boucher "Vegetation Response to Prescribed Fire in the Kenai Mountains, Alaska" available at KLWC, in FS computer files and elsewhere. Five prescribed burn units chosen for study lie inside the project area. Table 6 displays changes in species cover (burned vs. unburned) for all units, including those lying inside the project area. The burned areas (East Fork units) showed a general increase in moose browse production. The effect on other species of wildlife appears less clear.

Undated, untitled large format GIS map available at KLWC shows moose winter across the SRD. According to the map, winter range occurs in lower Resurrection Creek south of Hope, in lower Six Mile Creek around the settlement of Sunrise, in the Summit Lake/ Lower Summit Lake area including local tributary creeks and at the confluence of Granite, Bench, Lynx and East Fork of Six Mile creeks.

Available information in the files suggests that moose winter range occurs in the project area and that range condition stable or declining when judged by forage production. Personal communications with ADF&G biologists suggest a stable moose population over the most recent decade.

Bats

During the summer of 2001, Aaron Poe of the Glacier Ranger District surveyed bats by using ultrasonic detectors. He stationed five detectors in the Six Mile drainage and five detectors along the nearby Turnagain Arm coast and in lower Resurrection Creek. Internal FS report on the results of the survey not yet available as of February 14, 2002. Personal communication with Poe indicates that report may become available within one year. In the interim, refer to study plan entitled “Assessing Temporal Variation In Habitat Use By Forest Roosting Bats In Resurrection Drainage” available at KLWC. Personal communication with the technicians working on the project indicates that bats occurred at all 10 sites.

Mountain Goat

Map available at the Seward Ranger Station in the wildlife file cabinets in folder labeled “Goat Census/Harvest Reports”. During August and September of 1968, the Alaska Dept. of Fish & Game conducted an aerial alpine survey of sheep and goats. Although the census units did not align with the Canyon/Sixmile watershed, the unit that most closely did (334?) contained zero sheep and 60 goats. Adjoining ADF&G units also contained no sheep. According to personal communication with Ted Spraker of ADF&G, the same unit contained 130 goats in 2001.

The Canyon/Sixmile watershed encompasses parts of ADF&G census units 334, 332, and 333. ADF&G keeps records of censuses of various big game animals and can provide census data. Note that the census units do not align the Canyon/Sixmile watershed. Some lap into Canyon/Six Mile but also include areas many miles distant. Therefore, use circumspection when applying the census numbers.

Starting in 2000, Aaron Poe of the GRD began studying the response of mountain goats to helicopter noise. He intended to develop permitting guidelines based on population trends and the effects of helicopter-based recreation on goats. Of the eight goat ranges proposed for study, two (Mt. Alpenglow & Silvertip/Granite) lie within the Canyon/Six Mile area. Internal FS report not yet available. Personal communication with Poe indicates that report may become available within two years. In the interim refer to study plan entitled "Determining the Response of Mountain Goats to Disturbance from Helicopters" available at KLWC.

Chugach National Forest 1999 Monitoring Report shows a stable goat population for the most recent 5-year period for the eastern Kenai Peninsula as a whole.

Caribou
Part of the extreme northeast range of the Kenai Mountain herd lies in the upper Canyon and Six Mile drainages. ADF&G document titled "Caribou Captures, Killey River and Fox River Herds" available at SRD in wildlife files. Telemetry data from 1993 to 2001 show that some caribou enter the project area in August and September near upper Donaldson and upper Alder creeks.

Wolf
According to personal communication with Ted Spraker of ADF&G, a wolf pack known as the Silvertip Pack uses the project area, but not exclusively.

Wolverine
Some wolverine surveys were completed in the early 1990's in cooperation with the Alaska Department of Fish and Game.

Dall Sheep
Habitat is limited. AKFG counts in 2002 included 12 animals near upper Six Mile Cree, and 30 animals centered around Gilpatrick Mountain (personal communication with Ted Spraker, AKFG).

II. Forest Service Publications

Six Mile Salvage Sales Environmental Assessment, USDA Forest Service, Alaska Region R10-MB-324 1996 available at SRD and elsewhere. Pages 42 through 57 contain information about wildlife specific to the Six Mile drainage and specifically about the effects of various logging alternatives on individual species of wildlife. At 38,444 acres, the Six Mile Creek study area referenced in this document fits inside the much larger Canyon/Six Mile drainage including its tributary headwaters.

Document states that habitat exists for moose, mountain goat, Dall sheep, black bear, brown bear, bald eagle and marten. Figure 11 on page 45 quantifies an animal species diversity index for 12 vegetative communities. It also quantifies habitat capability for three classes of animals in four forested vegetative communities. Reports two bald eagle nests in the study area and identifies cottonwood generally as the preferred species for nest trees. Document states that two goshawk nests occur in the area, both in mountain hemlocks.

Document states that harlequin ducks breed in the watershed. A survey in 2000 for harlequin ducks in the area yielded evidence of breeding pairs on the SRD, but none on Six Mile Creek, an area specifically searched. Document states that marbled murrelets probably nest in the area. A 1995 survey of nesting murrelets in the area yielded no evidence of them.

Draft Document entitled **"A Conservation Assessment for the Kenai Wolverine of South-central Alaska"** by Susan Howell, 1999 available in FS computer files at WFT/wildlife/misc/wolverine. Author states that 1992 aerial track surveys of the Kenai Peninsula showed track concentrations along Six Mile and Canyon creeks, among others. Document also provides a good bibliography.

Draft document entitled **" Resurrection Creek Landscape Analysis, Hope, Alaska"** prepared by Hart Crowser, Inc. in 2001 available in FS computer files at WFT/watershed_analysis/res_creek. Although Resurrection Creek watershed lies outside the Canyon/Six Mile watershed, it also adjoins it, encompasses similar acreage and therefore can provide a realistic comparison area. Table 15 in the document lists the limiting habitat factors for moose, bald eagle, northern goshawk, caribou, brown bear, wolverine, harlequin duck and northern red-backed vole. Author states that lower Resurrection Creek may comprise the core winter range for moose in the Resurrection Pass, Six Mile and East Fork areas. Author also states that bark-beetle induced changes to forested part of the watershed may benefit moose by generating more young seral stages. Author reports five eagle nests in the area and suggests that area could support two additional territories except for the lack of suitable, large cottonwood nest trees. Author states that the Kenai Mountain herd of caribou (the same herd that strays into Six Mile) apparently does not mix with the lowland herd. Author reports eight goshawk nests in three territories. Based on a study by SRD personnel, the highest densities of voles occurred in spruce stands heavily infected with bark beetles. The lowest density occurred in an area burned in 1984.

Document entitled **"Hope Highway Wildlife Resource Report"** by Susan Howell available in FS computer files at wft/maryanns/hopehwy. Table 3 quantifies the value of 13 forest types to seven species of wildlife in the project area. Table 4 quantifies a habitat capability index for the project area at four time periods for each of seven management indicator species. Document contains a literature-cited section. Document probably constitutes the single best source of synthesized wildlife information specific to the project area.

Resurrection Creek & Palmer Creek Salvage Sales Environmental Assessment, USDA Forest Service R10-MB-328 1996. Pages 74 through 86 contain wildlife information specific to the forested portions of the Resurrection and Palmer creek drainages and specific to the effects of various logging proposals on wildlife. These drainages adjoin the Sixmile/Canyon drainage and provide a valid comparison unit.

Figure 15, page 76 provides an animal species diversity index for 11 generalized habitats. It also provides a habitat capability index for birds and for mammals for four forest types. The document identifies forest fragmentation as a primary issue. Figures 17 and 18 on pages 79 and 80 provide fragmentation metrics for various project alternatives. Document lists the indicators for evaluating effects on wildlife as forest fragmentation indices, production of moose browse, habitat capability indices, and cumulative effects on brown bears and goshawks.

Palmer/Resurrection "unit cards" available at KLWC in wildlife files. Two bound documents contain unit-specific 1995 field notes, comments, opportunities and concerns of various specialists including wildlife biologists who visited most of the 57 units of the Palmer/Resurrection timber sale. For many units, the wildlife authors had no comments. The authors identified negative impacts to squirrels, spruce grouse and associated passerines from the ongoing spruce die off. They also identified forest fragmentation, maintenance of old growth hemlock stands and recruitment of future old-growth spruce stands as concerns with various logging proposals. For several units, they identified opportunities to improve the quality of early seral habitat by logging and burning or by burning alone.

DATA NEEDS

1. An accurate GIS map of current old growth, with assessment of condition in relation to the spruce bark beetle (is it currently infected and expected to die, or if uninfected, what is the probability of infection?).
2. An accurate GIS map of current vegetation types and structure within the watershed.
3. An inventory and GIS maps of current species habitat use and locations of important use areas (nest, roosts, dens, summer and winter ranges etc.) of the MIS, TES, and SSI species in the watershed.
4. Population estimates and trends for MIS, TES, and SSI species in the watershed.

C. Vegetation

Composition and Distribution of Vegetated Communities

The current composition, distribution, and structure of plant communities in the assessment area has developed in response to various natural processes, the most major being wildfire, spruce bark beetle infestations, landslide, and avalanche. The predominance of rock and ice in the higher elevations throughout the watershed association contributes to the avalanche and landslide processes, and is also a major factor in influencing the structure and distribution of plant communities. Plant community structure and distribution has also been affected to some degree by past and present human uses, including mining and settlement as well as land use management activities such as timber harvest and prescribed burns. The current mosaic of plant communities has shaped the timber and fuels management activities that are underway for much of the assessment area. Stands throughout the Sixmile Creek area are included as treatment areas in the Hope Highway EA (2002).

Overall, the distribution of plant communities has not likely been much affected by human influence with a few exceptions, as only approximately 1% of the land area is directly affected at the present by human uses such as communities, mining claims, road corridors, parking areas, and others. The major determinants in vegetation composition are fire, spruce bark beetle, avalanche, landslide, and other natural processes.

In terms of cover type, 81% (142,041 acres) of the assessment area is Non Forested (Table 2), and only 19% (33,985 acres) is Forested (Table 3). Non Forested areas are concentrated on ridge tops and steep sideslopes of higher elevation, and most of the Forested areas are in the valley bottoms and the lower third of the sideslopes along the river and stream valleys. Of the Forested areas, the majority of cover type is in Hemlock-Spruce (7%, 13,060 acres) and Hemlock (7%, 12,706 acres). Several of the hemlock stands show interesting even-aged features, particularly along the Turnagain Arm and Sixmile Creek section of the assessment area, probably as a result of a massive windthrow disturbance. Many of the stands along Turnagain Arm show historical use from tie hacking activities in the early part of the 1900s including stumps and individual marks on standing trees.

Table 2 - Non Forested Cover Types	**Acres**	**Percent**
GRASS AND ALPINE	62,451	35
ROCK	31,462	18
OTHER BRUSH	24,838	14
ALDER	14,129	8
SNOW AND ICE	6,770	4
WATER	915	1
OTHER NON FORESTED	491	0
MUSKEG MEADOW	241	0
WILLOW	532	0
NON NATIONAL FOREST LAND	207	0
NONSTOCKED	5	0
	142,041	81

Table 3 – Forested Cover Types	**Acres**	**Percent**
HEMLOCK-SPRUCE	13,060	7
HEMLOCK	12,706	7
BIRCH	3,202	2
MIXED HARDWOOD-SOFTWOOD	2,388	1
WHITE SPRUCE	1,335	1
SITKA SPRUCE	655	0
COTTONWOOD	578	0
ASPEN	61	0
	33,985	19

Pure spruce stands account for less than 1% (655) acres of the assessment area but along with the spruce-hemlock stands and some of the mixed hardwood-softwood stands (1%, 2388 acres) are nearly all affected by the spruce bark beetle. Much of the spruce in all of these stands is dead or dying due to the infestation, leading to standing dead that are beginning to fall. There is little regeneration of spruce, which requires a mineral or disturbed area to seed. The Hope Highway EA (2002) prescriptions include creating open seedbed areas through slash pile burning and also planting spruce seedlings in other areas.

Throughout human occupation of the project area, the natural resources found in the forest have been and continue to be important resources for providing shelter, food, and fuel, and for later settlements, occupations to earn a living, such as guiding. Current human use of the assessment area is low, with approximately 1% of the land area in direct use such as structures, settlements, bridges, utility corridors, or road corridors.
With European settlement of this area, the natural resources were utilized and influenced by mining, community development, transportation development (highway and railroad building), and wood harvest. Signs of past use and product removal can still be seen in many areas of the project area including mining pits, stumps from tie hacking, and other wood harvest activities.

Residential and commercial development by humans has had low to moderate impacts on existing plant community structure and distribution within a small proportion of the entire assessment area. Impacts outside the developed areas have been low. The major effect in human-influenced areas includes replacement or alteration of mature spruce and hemlock-dominated types to an earlier successional or seral stage vegetation type, such as birch or mixed hardwood-softwood types. Other alterations of cover type and seral stage include various vegetation removal activities, human-induced wildfires, and prescribed burns. Areas where vegetation has been altered but not permanent removed will have plant communities will shift to early seral types including brush (alder, willow), hardwood types (birch, cottonwood) and mixed types (birch-spruce, cottonwood-spruce). In almost every case, human-related impacts are confined to the lower one third of the watershed associations, as roads, mining access, recreational access, cabins and campgrounds, and other developments are contained in areas easier to access due to terrain and stability.

Development in Response to Process

Fire

Fire is believed to be an important disturbance process over many millennia in south-central Alaska, and can dramatically alter the vegetation composition of a forest (Sixmile Salvage Sales EA 1996). Both historic wildfire (before European settlement) and more recent fires have contributed to the mosaic of vegetation types that exist today, especially the presence of early to mid-seral phases of hardwood and mixed types and alder scrub (DeVelice et. al 1999). Most fires that occur are stand-replacing. Wildfire and past and present spruce bark beetle infestations have had a prominent influence on the composition and structure of the forested landscape of the Kenai Peninsula (Potkin 1997). Wildfire has increased since European settlement, particularly around developed areas. When the steam engine was still in use, until about 1954, many relatively small-sized fires were common from sparks from the engines, concentrated along the railroad corridors throughout the Kenai Peninsula. Approximately 99 percent of all fires on the Chugach National Forest are human-caused (Potkin 1997). While not unheard of, only three occurrences of natural lightning strike were reported in the last century, meaning natural lighting-strike fires are not a frequent cause of ignition. These wildfires have decreased in acreages burned as fire prevention techniques improved following the end of the steam engine era around 1953.

The long interval fire cycle may have historically controlled the recruitment and mortality of spruce and hemlock trees in this forest over the past 500 to 3,000 years. The Hope fires (1904-1930) in Cripple Creek, Bear Creek, and Sunrise burned at least 6,000 acres cumulatively (Potkin 1997). These human caused fires created a landscape of early successional or seral stage vegetation. Fires have decreased in size as fire prevention techniques improved and with the end of the steam engine era, allowing spruce and hemlock to become more dominant in these stands. Whether fires occur naturally or are human-caused, State and Federal agencies normally respond by putting them out to reduce the risk of damage or loss to human life and property. In doing so, a disturbance event with great potential to affect vegetation and alter ecosystems may be excluded from the environment (Sixmile Salvage Sales EA 1996).

Likelihood of fire is typically confined to a narrow window due to the moderate climate and high fuel moistures that persist most of the year except during periods of drought. Spruce trees are generally flammable in the late spring and early summer because of lower live moisture content and the presence of flammable resins and other volatile oils in their needles. Fire effects are variable and mosaics are often created with unburned islands. Fire risk is currently high due to the amount of dead and dying spruce trees throughout the entire assessment area, leading to high fuel loading figures. The concentration of fuel is in the core area of the assessment area, along the forested areas of the valleys where the roads, communities, and most of the trails are located. Fire hazard to the communities in the area is a growing concern given the current fuel loading amounts. Typical fuel loading for down woody debris in the forested areas ranges from around 6 tons/acre nearer the coast to over 15 tons per acre further inland. Standing dead tree fuel loading ranges from below one tons/acre in coastal stands to over 60 tons/acre in stands further inland.

Fire, given the right conditions, may provide the necessary disturbance for spruce regeneration and establishment to take place (Zasada and Viereck 1970, Zasada 1972, Schmid and Frye 1977). Without fire or some other site disturbance factor that can produce a mineral seedbed for regeneration in areas of the forest where *Calamagrostis canadensis* (bluejoint reedgrass) is represented, significant increases in this grass can be expected following spruce beetle outbreak with little or no regeneration of any tree species (Holsten et. al. 1995).

Fires scattered throughout the project area have created several stands of birch and mixed hardwood-softwood stands with variable shapes. These are generally located near the road and railroad corridors, and are visible along the first several miles of the Hope Highway and along parts of the Seward Highway near Granite Creek. In many of these stands there is a significant spruce understory developing.

Spruce Bark Beetle

In the past 20 years, more than 1,000,000 acres of spruce forest throughout southcentral Alaska have been impact by the spruce back beetle (*Dendroctonus rufipennis* Kirby). On the Kenai Peninsula, approximately 300,000 acres of ongoing infestations and newly infested spruce forests were identified with aerial detection in 1994 (Sixmile Salvage Sales EA 1996). Many residents and visitors feel that the forest is unhealthy and are concerned with the possibility of wildfire due to the dead and dying trees, especially around communities. Spruce bark beetle appears to be an integral part of the normal fire and successional process and existing plant community structure and distribution in the region. Natural outbreaks appear to occur at a cycle of 150 to 500 years.

Many of the large-sized stands with a spruce component have very closely spaced trees, which creates crowded and slow-growing conditions for the trees. Spruce trees in these stands become susceptible to the spruce bark beetle, resulting in dead and dying spruce trees. The dead trees eventually break off creating a jack-strawed pattern (Holsten, Werner, DeVelice 1994, Hard 1985). These characteristics change the habitat conditions for resident wildlife, make recreational travel more difficult, change the appearance of the forest, and reduce the commercial value of the trees (Hope Highway Hazard Reduction Silvicultural Diagnosis, Kesti 2000 Draft).

Spruce bark beetle infestation is significant in the project area in stands with trees pole-size or larger and where the spruce component exceeds 30% of the basal area. The spruce bark beetle epidemic peaked in 1996 in Alaska. The Sixmile Creek valley had experienced an up and down pattern of activity for the previous five years, and in 1998, populations rose by 82% to 545 acres. In 1998, further activity occurred since there was still considerable host material available (Wittwer 1998). Along the Hope Highway corridor, the amount of infested acres rose from 6 acres in 1990 to 5,677 acres in 1996 (Sixmile Salvage Sales EA 1996). The Hope Highway area is currently undergoing a fuel reduction project (Hope Highway EA 2002) in stands adjacent to the road, in the corridor between Sixmile Creek to the East and the Chugach Electric Powerline to the West. Much of the infected spruce is contained within this core zone although vast stands are not readily accessible for management activities.

Avalanche and Landslide

Most of the upper slopes in the assessment area are mapped as having high to moderate avalanche potential. Large snow avalanches can occur every 1 to 5 years (Blanchet 1983). The winter of 1999-2000 was a year of large avalanches for southcentral Alaska, with several causing serious damage. Approximately 15 acres of forest was pushed or blown over by snow and wind from an avalanche in this winter at about Mile 5.5 of the Hope Highway, which left the local communities without power for several days. About 5 more acres of surrounding timber sustained some damage. The wind generated by avalanches can cause extensive windthrow beyond where the snow debris ends. This type of wind damage can extend across drainages, affecting trees across the drainage. An avalanche in the winter of 2001-2002 at approximately Mile 3.5 of the Hope Highway pushed all the way across Sixmile Creek from the slopes on the east side to the edge of the Hope Highway, affecting a popular recreational goldpanning area and the associated parking area on the highway. Great walls of ice were still framing the river in mid-August of 2002 along Sixmile Creek, and huge bare tracks along the slope to the alpine were slowly filling in with annual vegetation and new shrubs.

Frequent landslides can prevent a conifer forest from becoming established, while infrequent landslide events provide a new seedbed for birch and spruce to regenerate. Areas subjected to frequent landslides tend to cycle through early successional stages and do not become established with conifer trees. Due to the steep slopes throughout much of the assessment area, landslides do occur with some frequency, sometimes in conjunction with avalanches. Affects on vegetation are similar to that of avalanches. Generally the same areas along the sideslopes are affected year after year by avalanche or landslide, which prevents the vegetation from going much beyond early successional stages.

Mining

Mining has directly altered the current vegetation composition and structure in small areas, typically confined to riparian areas. Sixmile Creek has had the most mining along it within the assessment area and there is evidence of some mining activity in tributaries. Current use for rock removal is generally along Sixmile Creek and rock pits along the Hope Highway where access to road systems is good. Mining activities, by creating clearings and disturbed patches, allows pioneer and disturbance species to colonize the area. In riparian and floodplain vegetation community types, common vegetation includes brush, alder, willow, and cottonwood. Roadside rock pits and other terrestrial areas will often become populated with fireweeds, willow, alder, bluejoint reedgrass, and various other undesirable non natives or weedy species.

Local residents have used various areas along the Hope Highway for removal of rock for personal and commercial use. In recent times, during the winter of 2000-2001, river rock had been removed by hand from Sixmile Creek at Mile 2-3 of the Hope Highway. Slate slabs have been excavated by hand and transported by ATV in an area located ½ mile off the Hope Highway at Mile 11.5. Other requests for these types of product may increase in the future (Personal Communication Donna Peterson, USDA Forest Service Minerals Specialist 2001).

Wind

Wind damage can occur in conjunction with other events such as avalanches or it can cause damage to stands of trees during changing weather patterns. In the assessment area, the breaking off of tops of spruce trees during high wind events and blowdown of small pockets of trees (less than ¼ acre in size) are common. There is no recent evidence (within the past 100 years) of large wind events where trees are blown down over more than an acre of area except when the wind is generated by avalanches.

Roads and Corridors

The Chugach Forest Plan prescribes 1406 acres for transportation or utility corridor use. Roads throughout the assessment area include the Seward Highway and the Hope Highway, including the wye where these roads meet. There are several short Forest Service roads that spur off the Seward Highway. Vegetation will be periodically removed along utility corridors, including the Chugach Electric powerline which runs parallel to the Hope Highway. As part of the Hope Highway project (Hope Highway EA 2002) individual hazard trees will be felled along the power line corridor. Generally clearing takes place every five years, keeping the vegetation in the corridors at an early successional stage.

Subsistence

The community of Sunrise is on state land within the assessment area. Residents depend heavily on subsistence use of parts of the assessment area. Houselogs, sawtimber, fuelwood, and special forest products (Christmas trees, burls, berries, willow cuttings, etc.) are all products requested by the public. There is an increasing demand for green sawtimber and a decreasing supply of green high quality spruce trees due to past harvesting and bark beetle infestation and resulting tree mortality. Along the roaded portion of the Chugach National Forest, there are only a few areas left where quality live spruce trees are found, which includes the Hope Highway corridor. The demand for harvesting free use timber as permitted by federal regulation far exceeds the supply. (Karen Kromrey, USFS Forester, Personal Communication 2000). Along the Hope Highway, fuelwood, houselogs, and sawtimber are the products of greatest demand. The Hope Highway has Lutz spruce trees that have more of the Sitka spruce-like qualities that make high quality houselogs and sawtimber. Along the Hope Highway and other areas within the assessment area, past harvesting of wood products has caused problems such as slash build-up leading to a higher fuel load, high stumps, no planned regeneration of the areas, and incomplete utilization of felled trees (Hope Highway EA 2002). Part of the Hope Highway project (2002) is designed to provide wood products to the public from harvest activities where feasible by highway access and terrain, and to reduce the slash pile buildup to lower the fuel load. The road-access areas of the assessment area will continue to have high demand for forest products, and continued vegetation effects, although overall these will be small in terms of effecting vegetation composition and structure. However, these areas are the most visible to the public and to residents.

Structure of Vegetated Communities

The amount and distribution of different structure types by size class is critically important not only to the overall health and perpetuation of a vegetated ecosystem but also to the wildlife species dependent on various food sources and other habitat needs from these stages. Due to the disturbance history of the assessment area, the distribution by size class of the forested stands is not entirely desirable for maximizing terrestrial habitat used by wildlife. Table 4 gives the amount and percent for both the forested portion of the assessment area and the entire area. There is a percent (4% overall) of information missing for stands in the GIS database for Timber Type, where these figures are taken from (Chugach National Forest Resource Information Management Data Dictionary 2001). These size classes are analogous to the Oliver and Larson (1996) stand development stages of Stand Initiation (seedling/sapling), Stem Exclusion (pole timber), Understory Reinitiation (saw timber) and Old Growth (old growth saw timber).

In terms of the forested areas, 22% of the stands are not classified into a stand size class. The vast majority of forested stands (56%) are in the Stem Exclusion stage, with only 7% in Stand Initiation, 3% in Understory Reinitiation, and 12 % in Old Growth.

Table 4 – Stand Structure

Forested Stand Size Class	Stand Development Stage	Acres	Percent of Forested Acres
Not Classified		7,460	22
Seedling/Sapling (5”-9” dbh)	Stand Initiation	2,523	7
Pole Timber (9” – 15” dbh)	Stem Exclusion	19,229	56
Saw Timber (15” - 25” dbh)	Understory Reinitiation	1,006	3
Old Growth Saw Timber (>25” dbh)	Old Growth	3,969	12
Total		34,187	100

All Stand Size Classes	Stand Development Stage	Acres	Percent of Total Acres in Assessment Area
Non Forested		141,863	81
Not Classified		7,460	4
Seedling/Sapling (5”-9” dbh)	Stand Initiation	2,523	1
Pole Timber (9” – 15” dbh)	Stem Exclusion	19,229	11
Saw Timber (15” - 25” dbh)	Understory Reinitiation	1,006	1
Old Growth Saw Timber (>25” dbh)	Old Growth	3,969	2
Total		176,050	100

Ideally, a landscape would have an even mix of these for stand development stages for wildlife habitat and forested ecosystem health, or 25% in each stage or size class, by species. Table 5 gives the amount in acres and percent of stand size class or stand development class by major overstory species or species mix. This information is also derived from the Chugach GIS Timber Type layer. Pure hemlock stands are in a distribution of 58% stem exclusion and 2% stand initiation, with 40% of the stands unclassified. This distribution, even with the missing information, is not close to the desired 25% per stand development class. In birch, a hardwood species important for wildlife habitat and browse, only 1% is not classified, 68% is in stand initiation, and 31% is in stem exclusion, with no percents in the larger stand development classes, which is related to the past developmental history of the forested stands in the assessment area. The hemlock spruce mixes are heavily distributed into the stem exclusion stage at 66% for hemlock-Sitka spruce and 90% for hemlock-white spruce. In some cases, such as cottonwood-Sitka spruce mix, there is a higher percentage in Understory Reinitiation (53%); however with the spruce bark beetle epidemic this likely will change as larger diameter spruce die off or have already died.

Table 5 - Size and Stand Development Class by Species

Species	Stand Size Class	Stand Development Class	Acres	Percent by Species	Percent Total Landscape
Non Forested			141,863	100	81
Hemlock	Not Classified		5,090	40	3
	Seedling/Sapling	Stand Initiation	235	2	0
	Pole Timber	Stem Exclusion	7,379	58	4
Total			12,704	100	7
Sitka Spruce	Not Classified		256	39	0
	Seedling/Sapling	Stand Initiation	16	2	0
	Pole Timber	Stem Exclusion	20	3	0
	Saw Timber	Understory Reinitiation	37	6	0
	Old Growth Saw	Old Growth	326	50	0

	Timber				
Total			655	100	0
White Spruce	Not Classified		190	14	0
	Seedling/Sapling	Stand Initiation	89	7	0
	Pole Timber	Stem Exclusion	674	50	0
	Saw Timber	Understory Reinitiation	34	3	0
	Old Growth Saw Timber	Old Growth	349	26	0
Total			1,336	100	1
Birch	Not Classified		23	1	0
	Seedling/Sapling	Stand Initiation	2,177	68	1
	Pole Timber	Stem Exclusion	1,001	31	1
Total			3,201	100	2
Aspen	Seedling/Sapling	Stand Initiation	6	10	0
	Pole Timber	Stem Exclusion	55	90	0
Total			61	100	0
Cottonwood	Not Classified		12	2	0
	Pole Timber	Stem Exclusion	132	25	0
	Saw Timber	Understory Reinitiation	297	55	0
	Old Growth Saw Timber	Old Growth	95	18	0
Total			536	100	0
Hemlock-Sitka Spruce	Pole Timber	Stem Exclusion	5,819	66	3
	Saw Timber	Understory Reinitiation	85	1	0
	Old Growth Saw	Old Growth	2,935	33	2

	Timber				
Total			8,839	100	5
Hemlock-White Spruce	Pole Timber	Stem Exclusion	3,809	90	2
	Saw Timber	Understory Reinitiation	145	3	0
	Old Growth Saw Timber	Old Growth	263	6	0
Total			4,217	100	2
Birch-White Spruce	Not Classified		1,274	100	1
Cottonwood-Sitka Spruce	Saw Timber	Understory Reinitiation	70	11	0
	Pole Timber	Stem Exclusion	298	47	0
	Saw Timber	Understory Reinitiation	338	53	0
	Old Growth Saw Timber	Old Growth	1	0	0
Total			637	100	0
Cottonwood-Birch	Pole Timber	Stem Exclusion	42	100	0
Birch-Sitka Spruce	Not Classified		408	100	0
No Data			207	100	0
Grand Total			176,050		100

Sensitive Plants

There are two documented rare plant occurrences with the assessment area, *Potentilla drummondii* (Drummond cinquefoil), ranked G5 S1 (see Table 4), and *Smilacina stellata* (false solomons-seal). There are two additional plant populations of note close of the assessment area boundary, including the rare *Carex preslii* (Presl sedge), ranked G4 S1, which is 2.6 miles away from the assessment area, and the sensitive *Aphragmus* *eschscholtzianus* (Eschscholtz's little nightmare), ranked G3 S3, which is about a mile away and is on the Region 10 Sensitive Plant List. While the first three plants are not on the Region 10 Sensitive Plant List, they are considered by the Alaska Natural Heritage Program to be rare within the state of Alaska and populations are tracked (Lipkin and Murray 1997).

Table 6 - Global and State Rare Plant Rankings

Species Global Rankings
G1: Critically imperiled globally.
G2: Imperiled globally.
G3: Rare or uncommon globally.
G4: Apparently secure globally, but cause for long-term concern.
G5: Demonstrably secure globally
Species State Rankings
S1: Critically imperiled in state.
S2: Imperiled in state.
S3: Rare or uncommon in state.
S4: Apparently secure in state, but with cause for long-term concern.
S5: Demonstrably secure in state.

Sensitive and rare plants, like other plants, are influenced by various biological, chemical, and physical environmental gradients or regimes. A habitat diversity model combining bioclimatic, landcover, and landtypes GIS database layers into a single GIS layer was developed to identify and model various bioenvironmental regimes for sensitive plants. The bioenvironmental database was used to create maps of the potential distribution of all rare and sensitive vascular plant species known or suspected to occur on the Chugach National Forest. Maps were created by comparing characteristics of the different bioenvironmental model regimes to potential habitat for each of the 13 species of the sensitive plants of Region 10 that are known or suspected to occur. Of these, 9 are identified as potentially occurring in the assessment area. Further projects that occur in the assessment area should cause no impact to known or suspected populations of these plants.

Noxious Weeds and Nonnative Species

Both natural processes such as fire, avalanche, and landslide, and human-caused disturbance, such as road-building, mining, prescribed burning, and vegetation clearing have provided for the introduction of noxious weeds and nonnative species into the assessment area. Noxious weeds and nonnatives are primarily confined to immediate areas around developed and disturbed areas within the lower third of the watershed. Generally, noxious weeds and nonnatives are found along roadsides and parking area, in mine pits, at trailheads, along trails to one mile from the entrance, in cleared areas near road access, and in stands near the roads. Vehicles and humans (via clothing and shoes) are vectors for dispersal and spread of these plants as seeds cling to vehicles and people and are transported to new areas, spreading the distribution of these plants. Although the distribution and abundance of these plants has not been the subject of detailed investigation or precisely mapped, they are not generally displacing or threatening native plant distribution and abundance at this point (DeVelice, personal communication 2002) although populations should be monitored for change or increase, or new species introductions. Along riparian corridors, there is great potential for rapid spread of such species as *Trifolium repens, Taraxacum officinalis, Melilotus alba, and M. officinalis.* Roadsides, pullouts, construction areas, and trailheads can support populations of *Linaria vulgaris, Taraxacum officinalis, Trifolium repens*, and others. Threats from introduction of new species also exist with a growing tourist industry bringing more and more visitors to this area, and Alaska is still in a unique position to prevent populations through monitoring and education before they become entrenched problems (Boughton and Shephard 2002).

Vegetation Reference Conditions

Pre-European Settlement Conditions

In pre-European settlement days, continuous conifer cover would have dominated the project area much like the current conditions in the Primrose-Snow River area. Terrestrial wildlife habitat would have highlighted by unfragmented forested dispersal corridors for species like marten, lynx, and brown bear.

Sixmile creek or Canyon creek watersheds lack a good historical record or any detailed descriptions of vegetation prior to European settlement. With the lack of vast human-caused disturbance outside of places within the lower one-third of the watershed, much of the remaining undeveloped areas can represent the reference conditions, particularly on the upper slopes, steep side slopes, and nonforested areas. The same major natural disturbance processes would have been at work in the assessment area, including fire, spruce bark beetle, other insect or disease, avalanche and landslide, and wind. The role of fire may have been less with fewer opportunities for ignition, resulting in overall a more even distribution of stand development stages and better wildlife habitat. Prior to the settlement period, the majority of the conifer forest was recorded as being in late successional stages.

Stump record reveals large burned stumps within fire disturbance areas, although little work has been done or documented on these observations (Karen Kromrey, Forester, Field Observations 2000). The spruce bark beetle epidemic has obviously altered the current forest, and long-term structural changes may not be evident yet; however historically the same kind of epidemic likely occurred, which influenced the composition and distribution of forested types.

Hardwood stands were less prevalent and have persisted around communities and along the Hope Highway due to management and human activity. Historically, there were less hardwood stands that have arisen due to stand-replacing fires, and have been slow to reestablish especially with the spruce bark beetle influence on the spruce tree population.

Historical Fire and Bark Beetle Influence

By extrapolation, fire frequency was likely lower than it is now prior to European settlement of the assessment area because the recorded lightning strike record of naturally caused fires is low for the last century. Although large historical fires were recorded on the Chugach National Forest land area during the settlement period, there is no record of the number and size of fires during the prehistoric period. Although there has not been much investigation into the historical fire frequency, guessed formed by looking at similar areas and burned-stump records suggest that large stand-replacing fires occurred at long intervals, usually ranging between 250 and 500 years. Return intervals were somewhere between 100 to more than 600 years. These occur under extreme events of low fuel moisture, high temperature, low relative humidity, and high winds.

Historical spruce bark beetle infestations were also likely within the assessment area, resulting in large tracts of dead, dying, and infested spruce, much as today's conditions. These conditions predisposed the forested areas to large, stand-replacing fires. The fires were allowed to burn based on fuel availability as there were no suppression efforts. Generally in the historical record, outside of massive spruce bark beetle epidemics, the fuel moisture in the region and lack of fuel loading limited most to small intensity and size fires with less ecological impact on the greater landscape. Regeneration of spruce during such epidemics may have been helped by mineral seedbeds created after large, stand-replacing fires resulting from heavy fuel loads that were allowed to burn free, perpetuating the mosaic of vegetation types, including healthy spruce stands of all ages which are missing in the current composition.

V. Synthesis and Interpretation

Spruce Bark Beetle Infestation Effects

Spruce bark beetle infestation has led to an increased risk of fire and a short-term increase in large woody debris recruitment as more and more of the standing dead spruce fall to the ground. Efforts are underway to remove the dead and dying spruce through the Hope Highway fuels reduction project (Hope Highway EA 2002) using mechanical and hand removal of dead spruce, prescribed burning, and patchcutting with piling and burning of slash.

The level of fuel loading is high and will be reduced partially by management activities. There are still opportunities for more removal of dead, dying, and down spruce materials. Concern for the residents, structures, and community of Sunrise is still high. Following the initial surge in coarse woody debris recruitment due to the epidemic, the recruitment potential will be low compared to reference conditions for some time.

While the live spruce trees that are left are still susceptible to infestation by the spruce bark beetle, the epidemic appears to have stopped or significantly slowed due to the lack of food source for the beetles. Regeneration of spruce has been hampered by lack of seed source and by lack of bedding opportunity due to fire suppression and overwhelming amounts of downed woody material that covers the potential seedbeds for spruce seedlings to become established. The Hope Highway project (2002) also provides for planting of spruce seedlings and birch seed in areas where regeneration is desirable but natural regeneration may not be timely. Competition with *Calamagrostis canadensis* (bluejoint reedgrass) in open spaces usually makes conditions impossible for spruce seedlings to become established. In many areas along the Hope Highway and parts of the Seward Highway in the assessment area, habitat conditions are favorable for the growth of the bluejoint reedgrass over the recruitment of new trees (Boucher Thesis 2001).

Stand Structure Composition and Distribution

Changes in the structure of the vegetation communities is already underway, in some places with dramatic effects. Most spruce-hemlock stands are now only hemlock stands, and these are filled with boles and fine fuels from the dead spruce trees. In many places there are pure stands of dead spruce with very little for a tree understory. Many of these are visible from the Hope Highway and the Seward Highway and depending on individual perception can be considered unsightly in terms of scenic beauty. Lack of regeneration in these stands with heavy residual hemlock cover or lack of seedbed for seedling recruitment will affect the future species and stand development stage distribution throughout the assessment area.

Current hardwood and mixed softwood-hardwood stands have resulted from past spot fires, management activities, or some kind of disturbance. Natural disturbance processes will continue to allow hardwood regeneration in places resulting in new stand development classes for species such as birch and even some aspen in the assessment area. However, the aspen stands and many of the birch stands are decadent, and some have a spruce understory present. Many of the current hardwood stands or mixed stands are not being replaced successionally by spruce or spruce mixes because of fire suppression efforts and spruce bark beetle epidemic limiting the seed source.

Mining Effects

Mining effects on the overall vegetation composition and structure across the landscape is low. However, areas with active and past mining have been stripped of vegetation and may take time to recover. There is great potential in mined areas for recruitment of nonnative and exotic species populations, particularly where mine sites are near or off of roads or commonly used riparian corridors. There is also potential for native species regeneration in such sites. The poor substrate in the riparian zones in mined areas will take a long time to redevelop.

CHAPTER 3: KEY QUESTIONS AND ISSUES

1. Identification of social issues and key questions

Issues – Increasing recreation use demands, their impacts on the environment and to heritage resources. The questions that need to be answered are:

1) What is the current boating, rafting, camping, parking, and day use recreation impacts and are current, and future needs being adequately met?
2) What are the current trail conditions, and are the current trails meeting public needs?
3) Are there services and infrastructures adequate to met recreational users along the travel corridors, especially along the Sixmile Creek and dispersed recreation sites?
4) Is parking and specific on-site interpretative/education information being provided for the traveling public?
5) What dispersed camping use and impacts are occurring to the environment?
6) Are there additional cultural resources that have not yet been surveyed?
7) Are prehistoric and historic cultural resources in the area eligible for the National Register of Historic Places?
8) Is adequate interpretation of prehistoric and historic cultural sites provided for recreation users of the area?
9) How have heritage resources been affected by mining, and dispersed recreational use?
10) How have past management efforts affected heritage resources?
11) What state land selections, within the watershed, will actually be conveyed to the state?
12) How will these state land conveyances, and their potential development, affect current and future recreation use within the watershed?

Important regulatory constraints influencing the management of the analysis area is the recently Revised Chugach National Forest Land and Resource Management Plan, the Recreation Opportunity Spectrum (ROS) classification of Roaded Natural (RN) along the Seward and Hope Highways. There are also Forest Closure Orders for Camping Period Limitations (refers to contractors also that may be working on projects identified in this analysis), Recreation Site (number of campers) Limitations, Saddle and Pack Animal limitations within 200’ of trail and streams as well as timing limitations, Storage of Food Items and Refuse in the Tenderfoot Campground, Vehicle Use Limitations on Forest Development Roads and Trails, Motor Vehicle Load Limits, Seasonal Closure to Motorized Vehicles (primarily snowmachines) on Mills Creek Road and Manitoba Mountain area, Wild & Scenic river management, and Viewshed Corridor management.

Important ecosystem elements needing more detailed analysis would include projects that would meet visitor expectations, comfort, and safety.

2. Identification of cultural resource issues and key questions

1. Prehistoric cultural resources: There are many concerns surrounding the Sixmile/Canyon Watershed project. Most importantly the lack of archaeological inventory completed in the area. There are four Native Alaskan cultural resources known to be present along the Sixmile/Canyon Creek Watershed project that have not been evaluated for significance. Also the impact of mining on archaeological sites in the area has not been evaluated. It is probable some sites were destroyed during placer and hydraulic mining of creek bottomlands.

2. Historic cultural resources: Events connected with late nineteenth and early twentieth century mining in the watershed are considered historically significant in the economic and demographic development of the south central Alaska. The remains of Pre-World War II mining camps and production sites are themselves considered cultural resources that are potentially eligible for the National Register of Historic Places. Thus, it becomes an issue as to completing the proper evaluation for such sites. Such resources include, but are not limited to, standing and ruined buildings, tailings piles, historic roads, machinery, ditches and other evidence of waterworks. As such, the effect of mining on historic cultural resources has been to create them.

3. Forest plan impacts: Some of the greatest concerns regarding the destruction of cultural site in the watershed, involve the implementation of directives outlined in the forest plan. These include stream restoration, recreation and trails and the building of new roads.

Stream restoration can have direct negative effects on both prehistoric and historic cultural sites. While the process of stream restoration can benefit in the long term by preventing the erosion of cultural features, it can harm such features by removing deposits that may contain cultural debris. Stream restoration may also include the disturbance or removal of tailings piles and mining ditches, which are themselves cultural features.

The building of recreation sites such as campgrounds and trails can have both direct and indirect negative effects on cultural resources. Direct effects occur when cultural sites are harmed or destroyed during the ground disturbing activities necessary to build the recreation sites. However, the indirect effect of the recreation sites can even be more harmful. Recreation sites serve to bring more people into the forest with easier access. Thus, there is a greater potential for destruction of archaeological sites from trampling and looting of artifacts.

Another concern is the building of new, and the use of existing access roads. As in the building of trails, the building of access roads has the potential direct negative effect of harming or destroying heritage sites during construction. Both the new and existing access roads indirectly affect sites by giving easier access to the public. This can create the potential for trampling and looting.

What have been the direct, indirect and cumulative effects of mining on the watershed?
The human activity of mining has directly and cumulatively created cultural resources whose eligibility for the National Register of Historic Places must now be considered. In several instances, this includes standing buildings for which the Federal government, in this case the Forest Service, is responsible under section 110 of the National Historic Preservation Act. It also includes responsibility for the care and management of these cultural resources, such that they are not damaged, as addressed by section 106 of the National Historic Preservation Act, and the Archaeological Resources Protection Act.

What have been the direct, indirect and cumulative effects of Spruce Bark Beetle on the watershed?
There has been little effect on the features and buildings that constitute historic properties, although some may have suffered from beetle-killed trees falling on them. The Spruce Bark Beetle epidemic has affected the vegetation of the landscape, in relation to the cultural properties, and may have changed the visual associations of some cultural landscapes. Until cultural landscapes are inventoried and evaluated the effects of Spruce Bark Beetle on cultural resources will be unknown.

What is the desired future condition of the watershed (50 years from now)?
The desired future condition of heritage resources in the Sixmile/Canyon Creek Watershed is legal compliance, and achievement of all the obligations that the Chugach National Forest has under various laws. This includes completion of a full watershed cultural resource inventory; documentation and evaluation of all known cultural resources for the National Register; rehabilitation of historic buildings, which would be available for administrative or public use; interpretation and signage of sites, districts and cultural landscapes for the public; and site protection and interpretation through stewardship programs.

How does the existing condition differ from the desired future condition?

Over 99% of the watershed remains uninventoried for cultural resources, such that the Chugach National Forest is currently out of compliance with NHPA section 110 and

Executive Order 11593. Of the 69 known cultural resources in the watershed, 68 either need to be better documented and evaluated for the National Register of Historic Places, or need to have evaluations and nominations completed. None of the known historic buildings eligible for the National Register have been rehabilitated, and there is no management or maintenance plans in place for them, putting the forest further out of compliance with NHPA section 110.II. Physical Setting

3. Identification of Hydrology and Water Quality issues and key questions

The following issues and key questions are related to water quantity, water quality, and channel morphology. Sixmile Creek is the only stream in the analysis area that is currently monitored for streamflow, and historic records are available from 1979 to 1990, and 1997 to present. With additional historic peak flow data for Cub, Donaldson, Fresno, and Granite Creeks, and several weather and snow monitoring sites, flow conditions throughout the watershed are well characterized. Water quality data are limited to isolated measurements taken between 1951 and 1994 on several streams throughout the analysis area. This limited amount of data shows possible effects of mining activities on water quality that occurred in the watershed. The effects of placer mining, roads, and other human influences have significant localized effects on the morphological condition of channel banks and floodplains. Key questions and issues for the Sixmile/Canyon Creek analysis area are summarized below.

- ***How do current and past placer mining operations (commercial and recreational) affect turbidity and heavy metal concentrations of stream water downstream of mine sites?***

  Chapter 2 (Current and reference conditions) presents a discussion of the measured effects of placer mining operations on water quality. Although short-term, localized increases in turbidity and lead have been observed downstream of certain placer mining sites, long-term effects are uncertain because of the limited time frame of the data. The data also suggest that the effects of placer mining diminish downstream, but it would be worthwhile to further study cumulative downstream effects on water quality as well as fish habitat. An understanding of the effects of different placer mining techniques on water quality would also help manage water quality problems.

- ***How has placer mining in channels throughout the analysis area altered channel morphology, and what effects have these changes had on hydrology, bank stability, floodplain integrity, erosion, and water quality?***

Large in-channel placer mining operations often remove riparian vegetation, reduce the amount of large woody debris in channels, straighten channels, alter floodplains, and increase flow velocities. Channel surveys of disturbed and undisturbed reaches would help characterize these changes and provide a model for channel restoration. Because water quality and fish habitat are important issues in this watershed, the magnitude and extent of eroding banks caused by placer mining operations should be addressed.

- ***How does the landslide area on the lower portion of Juneau Creek affect water quality and sedimentation downstream on Mills Creek and Canyon Creek?***

  The steep eroding hillslope in the lower portion of the Juneau Creek canyon contributes significant sediment to Juneau Creek, predominantly during mass movements that occur with heavy rainfall and snowmelt runoff. The extent to which this mass wasting increases turbidity over natural and placer mine-related levels on a daily basis is unknown, and turbidities have not been measured upstream and downstream of this site. Although turbidity diminishes downstream in Canyon Creek, this source of sediment can potentially affect fish habitat in Canyon Creek and spawning habitat in Sixmile Creek. Mitigation efforts to prevent future sliding are possible, although such efforts would be considerably difficult.

- ***How have flow regimes in the analysis area changed in response to the spruce bark beetle infestation, and what is the potential for future change?***

  Total runoff in areas affected by spruce bark beetle infestation should be expected to increase somewhat as trees continue to die because of reduced evapotranspiration rates. No noticeable increases in average flows on Sixmile Creek were measured during the period of record from 1979 to 2000. Because of the long time frame over which this process occurs, it is likely that the heavy understory growth in beetle-infested forests causes evapotranspiration to remain relatively high, despite the loss of the larger trees. Also, because only a small percentage of the watershed contains spruce forests, these effects are likely to be insignificant compared to natural variations in runoff. Continued flow monitoring would be helpful to monitor any long-term changes, but stream gauges do not exist on many of the streams that are most affected.

- ***How does motorized use on non-system roads contribute to erosion and sedimentation, and how do these processes affect water quality?***

  Many non-system roads are easily accessed from the Seward Highway and are experiencing increased motorized use. The effects of motorized use on hillslope erosion, sedimentation, and water quality in streams are largely undocumented. Visible eroding tracks are a cause for concern for small increases in turbidity in nearby streams.

- ***What are the past and potential water quality effects resulting from oil and gasoline spills on the Seward and Hope Highways?***

  Sixmile Creek, Granite Creek, East Fork Sixmile Creek, Canyon Creek, and the Summit Lakes are all bordered by the Seward and Hope Highways, which receive considerable traffic throughout the year. This presents the possibility that accidents involving vehicles carrying hazardous substances could spill oil and gasoline into streams in the watershed. These streams are generally well buffered from these highways, but the streams are adjacent to the highways in several places.

C. Limnology
2. Upper Summit Lake
3. Lower Summit Lake
4. Bench Lake
5. References

3. Identification of mining issues and key questions

i. Trespass occupancy and trespass structures

ii.

Although the level of mining that is presently occurring in the assessment area is generally referred to as hobby or recreational, never the less a number of trespass[19] cabins exist in the area and trespass occupancy[20] is occurring. In 1991-1992 Jim Voss, Forest Service Certified Mineral Examiner #31 did Surface Use Determinations on most of the cabins discussed below. Some of these cabins may have historic significance; some would not. All have been identified as trespasses on the national forest system lands. This is not intended to be an exhaustive list of all cabins/structures in the assessment area.

a. Lynx Creek Area

1. Whites Roadhouse

Several cabins exist in the Lynx Creek area. The "Whites Roadhouse" group of cabins is shown on the 1951 (limited revisions 1976) Seward C-7, Topographic map in W1/2 Sec. 9, T. 7 N., R. 1 E., of the Seward Meridian. They are covered by the "Discovery 1" mining claim, located Sept. 9, 2002, by Thomas Mobley, Brad Sathers, and Gerald Lauer; it is in

[19] A trespass structure is one that has no authorization to exist on National Forest system lands.
[20] another type of trespass involves occupancy of a structure that is not authorized. Occupancy consists of staying in, using, or taking possession of. The structure may be privately owned or Forest Service owned.

recorded status. The camp appears to be a mix of historic and more recent cabins/structures. The five cabins appear to be used as a hunting camp rather than for mining purposes. In the past, the Seward Ranger District posted these cabins as government property but the claimants removed the signs and currently hold possession of them. There is no approved plan of operations or any other authorization for use of these structures.

Figure 9. Recent cabin at Whites Roadhouse complex, on Lynx Creek

2. Jacobs cabin and Silver cabin

Farther upstream, there are two more cabins. Both are along the old access road (shown on the topographic map) on the east side of the creek. Jacobs cabin is in NW1/4 Sec. 16, T. 7 N., R. 1 E., of the Seward Meridian. It is a plywood cabin with green metal siding and glass windows. It is covered by the "Discovery 3" mining claim located Sept. 16, 2002, by Thomas Mobley, Brad Sathers, and Gerald Lauer; it is in recorded status. John Rader was the previous claimant; he may have built the cabin. Since the current claim was located in 200, the Forest Service may own this cabin. The silver cabin is farther up the creek; it is in the SE1/4 Sec 17, T. 7 N., R. 1 E., of the Seward Meridian. It is covered by "Legal" mining claim, located Oct. 6, 1956 by Matthew Rader and John Rader; it is in recorded status. Ownership of the silver cabin probably lies with the claimants. There is no approved plan of operations or any other authorization for use of Jacobs Cabin or the Silver Cabin.

Figure 10. Jacobs cabin on Lynx Creek. Carol Huber, Forest Geologist, on the left and Ann Allen, U.S.D.I. Bureau of Mines, on the right.

b. Walker Creek

1. East Walker Creek and West Walker Creek Cabins

These two cabins exist along Sixmile Creek, at the mouth of Walker Creek in the S1/2 Sec. 22, T. 9 N., R. 1 W., of the Seward Meridian. One lies on the east side and one on the west side of the Walker Creek. The cabin on the east side was built before 1910; the age of the other is unknown. Access is difficult because in order to access these cabins, Sixmile Creek must be crossed. An old tram has been used to access them in the past. I believe that these cabins have not been used in many years. The most recent claim filed over the site is “Take a Walk #2” located by Cam Newton in 1999; an abandoned and void decision was issued by BLM on Oct. 30, 2000. A previous claimant was given an opportunity to remove his structures from Walker Creek in 1980 after his claim became null and void, but he did not. Cabin ownership probably resides with the Forest Service. There is no approved plan of operations or any other authorization for use of these cabins.

c. Shell Mine Cabin

The Shell Mine cabin and shed are located in the NE¼ Sec. 25, T. 7 N., R. 2 W., of the Seward Meridian, at an elevation of about 3,800 feet. The structures are covered by “Shell Mine #4” mining claim located Sept. 15, 1995 by Michael E Palmquist; it is in recorded status. Ownership of the structures probably lies with the Forest Service, because they almost certainly are older than 1995. According to the Sherman and Hoekzema (1983) the structures may have been constructed in the 1950s. There is no approved plan of operations or any other authorization for use of these cabins.

d. Canyon Creek

Most of the trespass cabins in the assessment area are along Canyon Creek.

1. Joy and Wagner (Ray claim) cabins

The Joy cabin and the Wagner cabin are co-located on the east side of the Seward Highway, about mile 52, in the NE¼ Sec. 4, T. 7 N., R. 1 W., of the Seward Meridian. Both cabins were built within the last 25-30 years.   The Joy cabin is covered by “Roaring Mine” mining claim, located Feb. 23, 1982 by Norman Bucy, and transferred to John Trautner in 1994; it is in recorded status. A previous claimant built the cabin. A patent application (AA-72648) is on file with the BLM for the Roaring Mine, Ray #1, and eight other claims. The cabin probably belongs to John Trautner and not to the Forest Service. The Wagner Cabin is on the Ray #1 claim that was located on Feb. 23, 1982 by George Hayes, who sold it to John Trautner in 1983; it is in a recorded status. John Trautner may have built the cabin. There is no approved plan of operations or any other authorization for use of these cabins.

2. Heavens Gate cabin

There are actually 2 cabins on the Heavens Gate claim; there is an old collapsed cabin and a newer cabin built by the claimants Mark Gaede and Gary Lindman in the summer of 1982 (Voss, 1992). The Heavens Gate cabins are on the east side of the Seward Highway at about mile 53, in the NE¼ Sec. 33, T. 8 N., R. 1 W., of the Seward Meridian. The cabins are on the Heavens Gate #2 mining claim, which was located, Feb. 27, 1988, and deemed abandoned and void Feb. 12, 1996. The Forest Service posted the cabins in May 1996. The cabins have been abandoned to the Forest Service. There is no approved plan of operations or any other authorization for use of these cabins. Daniel and Donna Hartman located a new claim over the cabins on Feb. 13, 1996, called the Golden Hope #2; it is in a recorded status. The Hartmans have a currently approved plan of operations through Dec. 31, 2002 but it does not approve use of the cabin. The approved camp is a mobile trailer or tent.

Figure 11. New Heavens Gate cabin on Canyon Creek.

3. Cascade cabin

The Cascade cabin is situated on the east side of the Seward Highway near mile 53; it is in the NE¼ Sec. 4, T. 7 N., R. 1 E., of the Seward Meridian. It is flat-roofed, about 30 by 12 feet, partly built of logs, and has a front porch. The older part of the cabin was built of logs in 1972 by Bill Nordeen, a previous claimant. The later addition, of frame construction, was added on the log cabin several years later, probably in the 1975 to 1979 timeframe, according to Mr. Krizman (Voss, Cascade Report, 1992). The cabin is covered by "Cascade Number Two" mining claim, located July 2, 1986, by Henry Krizman, Gordon and Linda Ferguson, and Mike and Sheryl Uher; it is in recorded status. The Seward District Ranger notified the claimant in May 1992 that the cabin was not reasonably incidental to mining and that it constituted an unauthorized use of national forest land. Ownership of the cabin may vest with the Forest Service since the claim was located in 1986 and the cabins were built before that date. The cabins would belong to the claimants only if purchased from the original builder. The Forest Service has not asserted ownership. There is no approved plan of operations or any other authorization for use of this cabin.

4. Betty cabin

The present Betty cabin is situated on the east side of the Seward Highway near mile 54 and on the east side of Canyon Creek; it is in the SE¼ Sec. 28, T. 8 N., R. 1 W., of the Seward Meridian. The "Betty" cabin is actually located on the Big Rock mining claim. James Wolcott purchased the Big Rock mining claim in 1961. He constructed the cabin in

1965 (Voss, Betty Report, 1992). Because of a filing error Mr. Wolcott had to relocate the claim in 1988; it is currently in recorded status. The cabin is approximately 20 X 16 feet; it is of steel frame construction with metal siding and a metal roof. It has a porch across the front. There is also a small storage shed that is approximately 6 X 6 feet. Since the claimant built the cabin, he would be considered the owner. There is no approved plan of operations or any other authorization for use of this cabin.

There was an older Betty cabin. This cabin was next to the Seward Highway at mile 54 near the parking area, but it was on the west side of Canyon Creek. It was on the claim when Mr. Wolcott purchased it. Mr. Wolcott removed this cabin in 1988 or 1989 at the request of the Forest Service.

5. Triangle Cabin and Mills Creek ATCO Unit

The Triangle cabin was located along the north bank of Mills Creek, nearly 2 miles east of the point where Fresno Creek meets the highway. It was built in 1961 or later. A Forest Service fire crew burned it down in 1998.

An ATCO Unit was brought in after the Triangle Cabin was burned, probably in 1998. It is upstream a few hundred feet from the old cabin site. It is situated in the SE¼ sec. 27, T. 7 N., R. 1 W., of the Seward Meridian. It appears to be covered by a mining claim called Alie's #1 owned by Kenneth Paul May and others. The claim was located Jan. 18, 1988; it is currently in recorded status. There is no approved plan of operations or any other authorization for use of the ATCO.

6. Other cabins

The cabins listed above have been identified as in trespass. Authorized cabins are not listed. Other unauthorized cabins may exist in the assessment area.

B. Mineral materials

Although it has been the Forests policy for many years to make mineral materials available from national forest lands, it may be time to reevaluate. The state has deliberately included mineral materials sources in some of their land selections. See discussion on Attachment 6. Still, Alaska Department of Transportation (DOT) contractors come to the Forest Service for mineral materials. The issue is whether or not the Forest wants to deplete national forest mineral materials resources when the state controls mineral materials adequate for their needs.

Additionally, some mineral materials pits do not have an overall “pit plan” and some may not have had an EA done. Pits have been used for dumping of debris such as waste rock and organic debris.

C. Gates and Mining Roads

Roads originally built or created for access to mining or prospecting areas continue to exist and to be used in the assessment area. These include but are not limited to the Lynx Creek road, Mills Creek road, several access roads to Canyon Creek, roads to old gravel pits, Silvertip Creek road, Shell mine road, and Bertha Creek road. They are in various levels of use and repair. Some abuses are occurring. For example, there is no approved plan of operations for any claims on Lynx Creek. The Lynx Creek road is gated. The public cannot use this road for vehicular travel but the claimants and their friends and relatives are using it for nonmining purposes. Other roads are gated with claimants having exclusive use. Exclusive road use must be approved under a plan of operations or a in some cases a Special Use Permit. Exclusive road use must be reasonably incidental to mining operations and this is generally not the case. Many small-scale mining uses do not require roads; an ATV or foot trail would be reasonable access for these.

D. Cables Across Creeks

This has long been an issue on the Forest and in the assessment area. At one time, I inventoried a total of 7 such cables strung across Canyon Creek within a 3-mile stretch. Suction dredge miners often string these cables across the creek to attach their dredge to in order to anchor it in place. Sometimes the dredgers do not remove the cables when they finish dredging. This is a serious danger to kayakers, because some of these cables may be too low for them to pass safely under. No inventory has been done in many years and it is unknown whether such cables currently exist, and if so, how many and where.

4. Identification of fire/fuels issues and key questions

Area Fire Management

1. What effect has the Spruce Bark Beetle had on forest fuels, and fire suppression efforts in the assessment area to date?

To date, the effect of spruce tree mortality in the analysis area on forest fuels has been substantial. The Cooper Landing area underwent beetle attack in the late 1980's, early 1990's. The Moose Pass area underwent major attacks by beetles in the summers of 1993 and 1994. The effects of those later attacks started showing up in the Spring of 1995. Vast acreages of spruce forest died and the needles turned red. The remainder of the Seward Ranger District including the Sixmile Analysis area received beetle attack in the summers of 1994-1996.

The 1993 fire season on the Kenai Peninsula was longer and drier than usual. There was 1 (potential) lightning fire and 30 human caused fires suppressed by initial attack Fire Crews on the Seward Ranger District. Four fires exceeded 3 acres. Their size was related to the fuels present, weather and time of origin rather than effects of spruce bark beetle impact. Two of these were within the Sixmile Analysis area in Calamagrostis grass.

The majority of the fires were abandoned camp fires that burned 10-25' in diameter in the lower duff layer before detection and suppression. The largest, the Trail River Fire, started July 13th as an abandoned campfire on the shore of Kenai Lake. It was caught by afternoon winds and spread upslope, with associated ground and aerial fire to attain 12 acres before being stopped by initial attack forces. Suppression costs exceeded $120,000. This fire reacted as expected given the present fuels, weather and topography. Bark beetle caused mortality was not evident within the fire or in directly adjacent stands at the time. By the end of the 1994 fire season, large diameter spruce within adjacent stands had been killed by bark beetle.

In 1994, the Seward Ranger District had a total of 24 fires. Once again, most were abandoned campfires that spread little before detection and suppression. The 2nd Russian River Campground fire on 6/15/94 spread rapidly to 1/10 acre in grass (Calamagrostis canadensis) before being stopped, causing $20,000 in damage to a campground staircase.

The period between 1995 and 2002 were predominantly wet seasons on the Seward Ranger District with few fires annually, and occasionally a few fires between 10 to 87 acres. All fires exceeding 1 acre were predominantly in Calamagrostis grass. The largest fire was in the Sixmile Analysis Area, caused by the escape of a logging operation burn pile at the base of a steep slope in the Granite Creek drainage.

On June 25th, 2001, a 1,200 acre prescribed fire on the north shore of Kenai Lake, which had been ignited on June 15th, was hit by 10-15 mph winds at 2130 in the evening. By midnight there was a 100 acre spot directly adjacent to the unit, and a 25 acre spot ¾ of a mile away. During the following two days, the escaped portion of of the prescribed fire burned an additional 2,000 acres within the fire perimeter, within bug killed spruce stands and mixed spruce/hemlock stands. The hemlock stands within the fire perimeter, burned only a few feet in from the edge, with occasional spots in areas where the stand was more open. The duff layer within the solid hemlock stands was considerably deeper, wetter, and was more highly shaded, keeping relative humidities high. RAWS (Remote Automated Weather Stations) at Broadview and Kenai Lake were installed in 1964. The period of the North Shore Kenai Lake fire was the first time that either RAWS station did not receive rain for more than 10 days during the month of June since their installation.

Prior to 1993, the Seward Ranger District had an average of 9.71 fires per year for the previous 20 years. Excluding the Pothole Lake fire in 1991, the average fire size for that period was 1.83 acres. Both averages increased as a result of the 1993 and 1994 fire seasons, but decreased again as a result of successive fire seasons.

2. What are the effects of the Spruce Bark Beetle on forest fuels and fire suppression efforts in the assessment area 1 year from beetle attack?

Alaska's spruce trees burn more readily than tree species encountered in the lower 48 states. Resins and other chemicals in the needles, and low foliar (needle) moisture content are partially responsible for this. When a spruce tree in Alaska turns yellow or red after beetle attack, the needles becomes more flammable than a healthy spruce tree due to the loss of live fuel moisture. Trees attacked by beetles will also have patches of resin flowing down the bark which can provide the ladder for ground fires to climb the dead tree and increase the probability of torch crowning and spotting. In the presence of wind or slope, fire spread in spruce stands can be rapid, and resistance to control efforts can be high. Large scale aerial (crown) fires in closed canopy will spread until they encounter a different fuel type, a decrease in slope, or are knocked down by retardant from aircraft. Direct attack by ground forces has no effect on crown fires.

Needles begin to fade from dark green to pale yellowish-green as early as 1 month after attack and may remain that color until the following summer. In some cases, needle discoloration may not be noticeable until 1 year after the attack and sometimes not until the beetles have left the tree. By mid-summer, 1 year after attack, some needles will have dropped and the tree turns reddish brown. Crown fire potential will approach zero once the needles have dropped.

Increases of sunlight to the forest floor in spruce stands that have lost their needles will generate increased growth of bluejoint grass (Calamagrostis canadensis) where previously present in the understory. Calamagrostis grass is a fine fuel, which, when cured can spread fire rapidly to heavier fuels. Fire hazard due to Calamagrostis grass moderates after green-up, usually around June 10, and does not reappear until the first hard frost. In its green uncured state, the live fuel moisture present in Calamagrostis grass can retard fire spread.**(08)**

There are human caused fires on the Seward Ranger District every year. It is not possible to predict where they are most likely to occur. 99% of the fires on the Kenai Peninsula are human caused.1993 was the highest fire year on record for the last 28 years on the Seward Ranger District. There is evidence to support a theory that "high fire years" on the Kenai Peninsula come in pairs, roughly every 10-12 years. This theory was supported in 1993 and 1994 with double the previous 20 year average for both years. Conditions during those years are drier during the normal fire season, and these drier conditions extend beyond the normal mid July rains well into the month of September, although total number of acres burned during this extended period have previously been minimal.

Rates of spread and resistance to control of a fire will be dependent upon fuels, weather and topography at the point of origin, and availability and response time of initial attack resources. There have been major changes in the spruce component in the Sixmile Analysis Area. Most of the spruce stand is coming down, opening the canopy allowing lower relative humidities, the encroachment of Calamagrostis grass, and increasing the potential difficulty of initial attack. This can require significant changes in initial attack strategies in dead spruce stands. Fires can show increased rates of spread, size and intensity, depending upon current weather conditions.

3. What will be the effects of the Spruce Bark Beetle on forest fuels and fire suppression efforts in the analysis area beyond 5 years from beetle attack?

Spruce tree mortality on 100 percent of the forested land within the analysis area will have a major long term impact on forest fuels and associated fire behavior.

Three to five years following attack by beetles, needles will have dropped and the trees will appear silvery-gray. Within 1 to 5 years following death, fungi attack the standing trees, generally in the lower stem, causing deterioration of the wood. Within 3 to 10 years after death, spruce trees snap off in high winds at the point of fungi attack. After 10 years, most of the dead trees will be down and jackstrawed in varying densities. This is starting to take place in the spruce stands in the Sixmile Analysis area.

Spruce stands impacted by bark beetle will lose most or all trees over 5 inches in diameter, and in areas of heavy concentrations, most trees 3 inches in diameter and over. As the canopy opens, <u>Calamagrostis canadensis</u> will spread where already present, and may invade sites where not. In lightly stocked stands, the grass can dominate the understory within 1 to 2 years. In densely stocked stands, invasion may be delayed until some trees are blown down. After 10 years, most of the dead trees will be down and grass will dominate.

In the absence of fire, remaining spruce less than 5 inches in diameter will survive and grow. If the remaining spruce are later attacked by bark beetle, they will die leaving no spruce in the understory, with a mat of grass impenetrable by spruce seed.**(17)** Calamagrostis grass has a tendency to insulate the soil and make sites colder and wetter, reducing the ability to support tree growth. Regeneration from spruce seed will not take place in competition with Calamagrostis grass without soil disturbance. The grass can dominate the site for as long as 30 years and contribute to increased rates of fire spread when cured for that period. Low intensity fires within those areas would be expected to stimulate and increase the growth of Calamagrostis, at times up to 50%, and re-initiate the grass cycle. High intensity fires within those areas would tend to break the cycle by removing the duff layer and grass mat, setting back the Calamagrostis grass, exposing areas to mineral soil, and encouraging the growth of brush, hardwoods and conifers.

Eventually, various shrubs and hardwoods will begin to invade the site and take over. Hardwood stands seldom support fire spread, and "almost" never support crown fires in a mature state. During the shrub/ hardwood stage, some spruce will begin to enter the site when seed sources are available. After 30-50 years without additional site disturbance, spruce will again dominate after shading out grasses, shrubs and hardwoods. Low intensity fires during the shrub/hardwood stage could potentially kill the shrub/hardwoods and any spruce in the understory. Low intensity fires would favor the return of Calamagrostis grass and shrubs. Moderate intensity fires during the shrub/hardwood stage would kill the shrub/hardwoods and spruce in the understory, but actually stimulate basal sprouting in the hardwoods, and return a healthy hardwood forest. High intensity fires would be expected to return the site to the beginning of the shrub/hardwood stage.

Increases of sunlight to the forest floor in dying spruce and mixed conifer stands will favor establishment of grass, and then grass/brush fuel types among standing dead trees. Most fatalities and structure loss occur on fires in these fuel types. Grass and grass/brush are flashy fuels which, when cured, can spread fires rapidly under conditions of wind, slope, and low relative humidity. In Alaska, brush is seldom a hazardous component except under extreme fire weather conditions. High risk from wildfire spread on the East half of the Kenai Peninsula generally occurs in the Spring prior to greenup, and the Fall after the first killing frost, when grass fuels are cured. After greenup, live fuel moisture in the grass inhibits rapid fire spread. Small twigs and branches on standing dead spruce trees can contribute greatly to long range spotting under conditions of wind and slope. Dead and down jackstrawed spruce trees contribute to high intensity fires with extreme resistance to control by hand crews.

As fuel conditions change over time from standing green spruce forests to dead and downed spruce with a grass component, the flammability of the spruce stands will change. Fires in green spruce stands can be low intensity, slow moving fires, with low resistance to suppression efforts depending upon the temperature and relative humidity. In the presence of wind, slope, high temperatures and low relative humidity, they can be high intensity, fast moving fires, with high resistance to suppression efforts. During the 3-5 years when spruce has died but hasn't lost its needles, fire behavior can be extreme. During the 3-10 years after the spruce has lost its needles and prior to jackstrawing to the ground, flammability will decrease to less than that of green spruce, although fire spread may remain high in the presence of cured grass. After 10 years, when spruce has jackstrawed to the ground and been invaded by Calamagrostis grass, fires prior to greenup can be extreme intensity, fast moving, with extreme resistance to suppression efforts.

Currently, fires on the Seward Ranger District are suppressed at low public cost with little or no resource damage due to the fire or the suppression effort. Due to bark beetle induced changes to the spruce fuel type, this cost can be expected to climb, with possible resource damage occurring from the suppression effort as well as the fire. Under extreme fire behavior conditions, public cost in terms of fire suppression efforts in beetle killed stands could be extremely high, with potentially high levels of unacceptable resource damage done by the fire, as well as high levels of resource damage incurred by necessary suppression efforts. The cost of wildland fire suppression on the North Shore Kenai Lake fire exceeded 1.5 million dollars, with an additional cost for rehabilitation of mechanical firelines, road closures, and seeding.

Analysis of historical fire occurrence and weather patterns on the East half of the Kenai Peninsula indicate a marginal chance of extreme fire behavior conditions occurring. Interpretation of John See's weather and fire behavior analysis for the Cooper Landing project indicate less than a 2% chance of having a "bad" fire day each fire season, based on a 150 day fire season.**(28)** He broke the weather patterns into 6 classes that support fire. Other weather conditions and patterns would not support fire. All six classifications that would support a fire would yield a large fire as long as wind was present.

With these six conditions combined into one class, and using the previous frequency of occurrence, it was determined that there was less than a 2% chance of a wind event occurring on a day dry enough to support a fire in the Cooper Landing area. Cooper

Landing is historically the driest area within the Seward Ranger District. The Sixmile Analysis Area would be expected to be at considerably reduced risk.

The Cooper Landing area receives an average of 26.34 inches of precipitation annually. The Moose Pass area has a moister climate, with an average annual precipitation of 40 inches below timberline, or roughly 14 inches more annual precipitation than Cooper Landing. These are the two driest areas within the Seward Ranger District. The North Shore Kenai Lake fire took place in the Moose Pass area in 2001. Both areas are subject to periodic high winds at all times of the year. The Sixmile Analysis Area would be expected to have conditions considerably moister than either of these.

Regardless of the odds of having a wind event occurring on a day dry enough to support a large fire, an ignition is still required on that day in an appropriate location for that to be a problem. No matter how low the historical, statistical probability of the right weather parameters occurring in the presence of an ignition, there will always be risk present, and there will always be Murphy's Law! What can go wrong, will go wrong, and at the worst possible time. Average numbers of fires may not change, but as high risk fuel loadings accumulate on a massive scale, initial attack fire suppression efforts can be expected to take longer, and result in more acres burned before control. Some fires can be projected to escape initial attack, become large, and require the support of Class II or Class I fire suppression Overhead Teams. The North Shore Kenai Lake fire went directly from escape to a Type I Incident, with a Type I Incident Management Team.

6. Identification of fisheries issues and key questions

7. Identification of wildlife issues and key questions

Key Issues:

1. Increasing recreation pressure and development may affect wildlife in the watershed, especially the brown bear. Brown bear habitat effectiveness decreases as human disturbances increase. The creation of additional roads, trails, campgrounds and day use areas in the project area, especially near anadromous streams, will further decrease the habitat quality. Of particular concern is the growing recreational use of the Six Mile riparian area.

2. The spruce bark beetle is impacting wildlife habitat over time by reducing habitat diversity, especially for species dependant on old growth and mature spruce. An

increase in habitat is expected for wildlife species associated with open habitats dominated by grass and shrubs.

3. The moose population is in a slow decline as a result of successional changes. Moose are a keystone prey species. A decline in the moose population will trigger a domino effect in the brown bear, black bear, wolf and wolverine populations.

4. Wild fire risk from bark beetle induced fuel build up is increasing, and has the potential to impact large areas of wildlife habitat over time.

5. Current data is limited on vegetation composition and structure, which can help determine existing and potential species habitat.

6. Current data is limited on habitat, locations, and population trends within the watershed for all the Management Indicator species (MIS), threatened, endangered, and sensitive species (TES), and species of special interest (SSI).

7. Bald eagles select large cottonwood trees near anadromous streams for nest sites. The current cottonwood age class distribution is skewed to the stem exclusion stage as a result of mining. Active management is needed to ensure long-term retention and recruitment of nest trees.

8. The limited and disjunct nature of old growth negatively affects the density and distribution of several species and may restrict dispersal patterns across the north end of the Kenai Peninsula.

Key Questions:

1. Where are known populations, existing habitat and potential habitat of TES, MIS, and SSI within the Assessment Area?

2. What is the current abundance of these species? What are the limiting factors within the watershed?

3. What are the current habitat conditions for these species? How many acres occur in each habitat type? What percent occurs in each vegetative structural stage within each habitat type, and how is it distributed? What is the distribution and abundance

of key habitat components such as old growth, thermal and hiding cover, snags, and downed logs, and travel corridors?

4. How are disturbance processes (such as spruce bark beetle, fire, and human disturbance from recreation) affecting the current patterns and distribution of the wildlife habitat?

5. What are the current threats/risks to wildlife or habitat (recreation disturbance, high fire risk, bark beetle)? Which species or areas are at high risk?

6. How much impact does increasing motorized winter recreation affect species such as the brown bear and wolverine?

Will the large tracts of Kenai Peninsula Borough land and State of Alaska land at the confluence of Six Mile and East Fork creeks, and at the head of Canyon Creek near Summit Lake be developed in a way that does not adversely affect wildlife or habitat in the watershed?

Identification of vegetation issues and key questions

What are the major vegetation successional processes at work on the landscape and how, if in any way, have these changed since European settlement?

How have land management activities and human use influenced the existing vegetated community structure and distribution?

How has the spruce bark beetle infestation affected the plant community composition, structure, and function, and how will it continue to affect the landscape over time?

What is the role of fire in the landscape historically and currently, with changes caused by the spruce bark beetle epidemic?

What is the amount and distribution of stand structure types as they relate to wildlife habitat and landscape level plant community function?

How will the current use and process in the landscape affect sensitive plant populations, and/or cause changes in presence of nonnative and noxious weed species?

CHAPTER 4 Mitigation and Recommendations

1. Social/cultural Recommendations:

The main management component identified was recreation and heritage management. These concerns focused on human uses around the more popular recreation areas of Sixmile Creek, the three campgrounds, the trails & trailheads, and the soon to be constructed Iditarod NHT.

One objective would be to determine the impacts to the resources from current uses and planned future uses. In particular these impacts need to be determined for the Sixmile Creek area through a capacity use study to determine numbers of users allowed as well as an Environmental Assessment to determine the impacts of this use.

It would also be beneficial to have a condition survey for the current and future trails to determine their use by the public. Along with this survey would be a determination of existing and needed facilities (parking, toilets, signage, etc.) to accommodate the traveling and recreating public. The same determination should be done to determine the impacts to the environment in our more popular dispersed recreation use areas.

A complete inventory of the heritage resources within the analysis area is warranted. A complete survey is needed to determine the locations of these resources and interpretation opportunities should be explored. One way of achieving this would be to partner with interested entities for documentation and interpretation of heritage resources, and rehabilitation of historic buildings. The USFS could develop collaborative stewardship relationships with interested parties for protection and interpretation of heritage resources. In addition to bringing the USFS into closer compliance with National Historic Preservation Act section 110 and Executive Order 11593, completing a heritage resource inventory would also proactively make compliance with section 106 much easier, as resources and their eligibility for the National Register of Historic Places would already be known for specific project areas. The US Forest Service would establish an interpretative walking tour of heritage resources, and rehabilitate and/or maintain historic cabins in the watershed.

An analysis should be conducted to determine how state selected lands, will affect recreation on National Forest System Lands. This affect could be both positive and negative. Positive affects could be that current high use dispersed recreation sites could have access either restricted or denied, based on a new ownership pattern. This would be positive for the resources, but negative for the recreationists. These areas, when known, should be negotiated so as to allow access through a federal easement.

Recreation may also increase depending on state selection. If facilities such as day use areas, trails, resorts, restaurants, hotels, etc are eventually build on these lands, then the surrounding public lands could be impacted. An analysis will need to be done, if and when these unknowns become known.

Option 1. Showcase the Forest Service's Management of Alaska Mining History

Complete the inventory and evaluation of cultural resources of the watershed over a period of 40 years, building a predictive model from existing samples after completion of a survey of 45,000 acres, or 25% of the watershed. An estimate of the time necessary to complete a 25% sample is about 15 years. Although some of the districts, cultural landscapes, sites, buildings, structures and objects that are in the watershed have been documented, less than 1% of the watershed has been inventoried for cultural resources. A complete inventory will allow better interpretation of the significant historic Gold Rush period mining resources in the watershed. In addition to bringing the Forest into closer compliance with NHPA section 110 and Executive Order 11593, it will also proactively make compliance with section 106 much easier, as resources and their eligibility for the National Register will already be known for specific project areas.

Another way to showcase the Forest Service's management of Alaska's mining history, is to partner with interested entities for documentation, preservation, and interpretation of prehistoric and historic sites, cultural landscapes, and rehabilitation of historic buildings. Develop collaborative stewardship relationships with interested parties for protection and interpretation of cultural resources, and partner with university programs for research work to provide background information for management and interpretation. Because of the rich history of use by indigenous peoples, followed by Gold Rush miners and pioneers, there is a wealth of interested potential partners for a variety of cultural resource related projects.

A pilot stewardship partnership with an outfitter-guide for historic sites in Prince William Sound has already paved the way for such a stewardship project in the Sixmile/Canyon Creek Watershed area. Many of the members of the Alaska Mining Association (AMA) and Gold Panners Association of America (GPAA) are interested in the history of mining on the Kenai Peninsula, and within the Sixmile/Canyon Creek Watershed in particular. Three historical societies-Kenai Peninsula, Hope-Sunrise, and Alaska Historical Societies-have already demonstrated interest in partnering with the Chugach National Forest on documentation, preservation and interpretation of cultural resources in the Sixmile/Canyon Creek Watershed.

The supporters of the Kenai Mountains-Turnagain Arm National Heritage Corridor national legislation could also be approached to assist with documentation, preservation and interpretation. Although not yet passed, this legislation is being formulated specifically to "recognize, preserve and interpret the historic and modern resource development and cultural landscapes" of the corridor, "promote and facilitate public enjoyment of these resources", and "foster…cooperative planning and partnerships among communities within the heritage corridor, as well as among individuals, businesses, the corridor communities and borough, state and federal governments." The State of Alaska's Office of History and Archaeology staffs have partnered with the Forest in the past on historic research, and would be likely future partners, as would the University of Alaska Departments of Anthropology and History.

The forest should also manage cultural resources in conjunction with other resources. Human use of the Sixmile/Canyon Creek Watershed has been generally due to the presence of various biological, botanical, geological and hydrological resources. Managing, and interpreting for the public, other resources simultaneously will provide a holistic view of the natural resources that were important to the people who created the existing cultural resources of a given site.

Option 2. Lower level management of the cultural resources in the Sixmile/Canyon Creek Watershed.

Complete the inventory and evaluation of cultural resources of the watershed over a period of 80 years, building a predictive model from existing samples after completion of survey of 45,000 acres, or 25% of the watershed. An estimate of the time necessary to complete a 25% sample would be about 30 years. Project specific inventory of cultural resources would also continue, as projects would be initiated. Historic properties and cultural landscapes would be evaluated for the National Register for management purposes. Historic properties would be avoided if possible.

Develop partnerships with the Hope-Sunrise and Kenai Peninsula Borough Historical Societies for documentation, preservation, and interpretation of prehistoric and historic sites, cultural landscapes, and rehabilitation of historic buildings. Develop relationships with other partners if they indicate interest.

Interpret cultural resources only if necessary for mitigation of adverse effects.
Evaluate and maintain historic properties, such as White's Roadhouse (SEW-00105), but do not rehabilitate unless necessary for maintenance.

Manage cultural resources in conjunction with other resources. Human use of the Sixmile/Canyon Creek Watershed has been generally due to the presence of various biological, botanical, geological and hydrological resources. Managing, and interpreting for the public, other resources simultaneously, will provide a holistic view of the natural resources that were important to the people who created the existing cultural resources of a given site.

The Revised Forest Plan and the original forest plan both state in the Standards and Guidelines that no activities will take place on slopes greater than 72 percent without the consultation of a Soil Scientist or a landslide risk analysis. As can be seen in the empirical analysis, there may be a high potential for landslides on slopes greater than 56 percent when there is a restricting layer in the soil profile such as compact glacial till.

Although, soils with a water restriction layer have not been extensive enough to be mapped, they are known to occur as inclusions. Thus, when soil disturbing projects are planned in areas where slopes exceed 56 percent, the sites should be investigated for the potential of landslides prior to the design and implementation of all management activities.

Wetlands perform the very important hydrologic functions of water storage and regulation of water flow. Some wetlands include the greatest diversity of plant species of any other ecosystem. The Standards and Guidelines also specify that wetlands will be avoided by all soil disturbing activities unless there is absolutely no other alternative. The responsible action of any forest manager is to be aware of the type and locations of wetlands before the design and implementation of a project, and to include them in the design any time a soil disturbing activity is proposed.

2. Hydrology Recommendations

The following list summarizes possible mitigation measures that address hydrologic issues within the Sixmile/Canyon Creek analysis area. These projects have not been designed or evaluated, and this preliminary list serves to stimulate thought on various enhancement opportunities. These measures include mitigation of direct impacts on stream channels and floodplains as well as indirect effects on water quality, sedimentation, wetlands, and riparian areas.

1. ***Channel and floodplain restoration of Sixmile Creek along the first 2 miles downstream of the Canyon Creek confluence*****.** The west floodplain of Sixmile Creek was historically placer mined. The floodplain in this area remains in a disturbed state, with unvegetated tailings piles and ponds occupying excavated gravel pits. Streambanks are eroding, and a network of primitive roads covers the floodplain. Restoration measures could revegetate and restore the floodplain and stream banks to a natural form, integrating measures to improve fish habitat. Streambanks would be stabilized and channel complexity would be increased by incorporating large woody debris into the banks and creating pools for fish habitat. Ponds within the excavation pits in the placer mined area of the floodplain could be enhanced, and interconnecting channels could be constructed to provide fish habitat in Sixmile Creek. Although much of this portion of Sixmile Creek lies on lands owned by the State of Alaska, erosion and floodplain functionality have a direct effect on water quality, sedimentation, and flood conveyance in the downstream reaches of Sixmile Creek on US Forest Service lands.

2. ***Road closure or reconstruction on the Colorado Creek Road*****.** The Colorado Creek Road is a non-system road that currently extends 0.9 miles up the canyon and serves as access to a mining claim. This road is in danger of capturing Colorado Creek flows during significant flood events, as it occupies areas of active gravel deposition on the alluvial fan of Colorado Creek. As the Colorado Creek alluvial fan continues to aggrade, the stream elevation continues to rise, and the stream will eventually break from its current channel and form a new channel. In places, channel migration currently threatens to break the narrow berm separating the channel from the road. Vehicle traffic and erosion have also caused portions of the road surface to become depressions that capture runoff and streamflows. Very little maintenance has been conducted on the road. Mitigation measures to reconstruct the road and prevent the stream from capturing the road will preserve the road surface and prevent a large influx of sediment downstream into Canyon Creek and Lower Summit Lake. Road closure and rehabilitation would also prevent resource damage. Although the lower 0.25 miles of the road are on lands owned by the

State of Alaska, the majority of the road is on US Forest Service lands, and downstream effects occur on US Forest Service lands.

DI. ***Closure of selected powerline access roads*.** Many roads were built in the 1950’s to access the powerlines that run parallel to the Seward and Hope Highways. Some of these roads have not been maintained since the powerline upgrade in 1993, and some of these roads are currently obliterated, inaccessible, or undriveable. However, many of these roads still exist in an unmaintained state. Some powerline access roads on the Hope Highway cross delicate forested wetland and riparian areas, which would be severely damaged by motorized use. Increased use of these roads without maintenance could cause degradation of water quality and fish habitat in nearby streams. Some of these roads should be closed or maintained, depending on the needs identified by Chugach Electric Association, Inc. for access to the powerlines.

3. Mining Recommendations

A. Trespass occupancy and trespass structures

Continue to seek to resolve trespass and trespass occupancy and especially endeavor to prevent new trespass. However, the current level of diligence is not working very well. The regular minerals program work such as reviewing and approving plans of operations, monitoring current operations, working with law enforcement, and certain important time critical work such as dealing with appeals and litigation has top priority; this leaves little time for minerals personnel to work on trespass occupancy. I recommend that the Forest Service review and update their records concerning trespass cabins/structures/occupancy. Historical significance or lack thereof should be evaluated. Next, the Forest needs to determine which cabins should be removed and which cabins should remain. I recommend bringing in a detailer or hiring a temporary employee to work exclusively on the project. Trespass is long standing and some of these cabins will take several years to resolve. Resolution may take one of these three forms: 1. Remove the structure or have the claimant/other owner remove it, 2. Establish Forest Service ownership and a management plan for the structure, or 3. Authorize the structure under a Special Use Permit or Mining Plan of Operations. I estimate funding needed between $50,000 and $75,000, possibly more. All of the identified trespass in the assessment area is on the Seward Ranger District. This is not to say that there is no trespass on the Glacier Ranger District.

B. Mineral materials
Continue to make mineral materials available for local public uses. If no current EA (within the last 5 years) has been done for active pit/quarry, do an EA. Additionally, prepare a pit/quarry plan for each. A reserve fund should be set aside from mineral materials revenue to provide for interim and eventually final reclamation. Immediately cease dumping of waste materials into Forest Service pits until an EA and pit plan is completed. The reclamation plan can provide for conditions under which for any disposal of waste or fill materials will be allowed.

C. Gates and Mining Roads
Inventory and evaluate the need for mining access roads and for gates across them. Some roads may need to be reclaimed and some could be opened to public use. A plan of operations approval specifically covering road use is necessary for exclusive vehicular access by the claimant on any gated roads. Where not reasonably incidental to the mining operations, the claimant or mining operator should be denied vehicular access on roads which are closed to the public.

D. Cables Across Creeks
I recommend that the Forest Service inventory these cables and remove (or cause to be removed) any low hanging cables or any cables not in current use. The use of cables across creeks by suction dredgers must be approved under a mining plan of operations. I suggest putting miners on notice to remove any low hanging cables across creeks. If claimants/miners fail to do so within a designated time the Forest Service should remove them. Dangerously low hanging cable should be removed immediately. I recommend that the Forest Service inform miners that if they wish to use a cable across the creek to tie off on, they will need to them approved under their plan of operations. Their current plan can be amended detailing the use of the cable (what, where, how and when).

4. Fire/Fuels Recommendations

People living in any forested community face a threat of loss of life and property from wildfire. Wildfire is a natural part of the ecosystem, but living with the results is not always necessary, or an acceptable alternative.

Most of the time, natural systems operate in natural equilibrium. Conditions vary within some balanced range. Catastrophic reset events such as major floods, insect infestations, and fires throw the system out of equilibrium for a time, after which natural recovery processes begin to bring the system back into equilibrium. The "range of natural variability" includes both the dynamic equilibrium range and the catastrophic events.

"Fire control and other management practices in the past have greatly altered the character of the Nation's forests and in many cases have created conditions highly susceptible to drought, pests, and wildfire. A combination of an extended drought, pest epidemics, and wildfire has recently brought attention to the fragility of western forest ecosystems and the need for future management to be more sensitive to the ecology of these forests".**(15)**

Assessment of the fire, fuels and fire suppression interrelationships with the Bark Beetle epidemic in the Sixmile Landscape Analysis Area are complex, and difficult to describe adequately in terms of what **will** versus what **could** happen. The natural cycles present on the East half of the Kenai Peninsula are long term, which are the least understood. Major disturbance agents such as insects and fire play a periodic natural role, but the specific extent of that natural role in the Sixmile Analysis Area would be difficult if even possible to determine without extensive research.

Answers to some questions must be projected, based on small quantities of local historical information, and studies of better documented similar ecosystems outside the area. Regardless of what may or may not be considered natural, concern must be expressed over an increased **potential** threat by wildfire in bark beetle killed spruce forests.

Weather and topography in the Sixmile Analysis Area will remain the same. High risk fuels will accumulate at a rapid rate over a large percentage of the currently forested area as a direct result of the Spruce Bark Beetle epidemic.

Average wildfires on the Seward Ranger District are usually slow moving, low intensity fires, with low resistance to control. Suppression costs to the public, and resource damage are low. Wildfires originating or passing through affected spruce and spruce/mixed conifer stands can become fast moving, moderate to high intensity fires with high resistance to control. Suppression costs to the public, and resource damage can be expected to climb.

Human caused fires are the primary cause of wildfire on the East half of the Kenai Peninsula. Recreational use can be expected to increase in the area in the future. As access increases, increased numbers of fires can be expected in areas of previous low fire incidence.

Initial attack fire suppression resources on the Kenai Peninsula can be expected to remain at current levels.

Calamagrostis grass has the potential to become the dominant cover type in parts of the assessment area for a long period of time.

Silvicultural prescriptions for disturbance agents such as fire or fuels treatment can short circuit long term natural cycles and artificially return stands to productivity.

Treating high risk fuels is more economically efficient than accepting the costs of fire suppression and rehabilitation. Fuels treatment and the use of prescribed fire are designed to meet predetermined objectives. Wildfire results are not selective.

Residents of the Sixmile Analysis Area can expect an increased threat from wildfire due to increases in hazardous fuel buildups in the area. A pro-active approach on their part must include personal acceptance of the responsibility to modify their dwellings and the fuels on their private property to make them more fire safe. The State of Alaska is not chartered to expend funds for the benefit of private parties. The Forest Service can, since October, 2001, but availability of funds will more likely be focused on joint cooperative projects in short fire return ecosystems in the lower 48 than they will be in the long fire return intervals in the maritime ecosystem in Alaska. However, Defensible Space Workshops can be sponsored by the State Dept. of Forestry and the Forest Service in response to public need.

Emphasis needs to be placed on making the touring public more aware of the increased wildfire risk on the Kenai Peninsula. Fire Prevention awareness and efforts need to be increased by both the Forest Service and the State Dept. of Forestry.

Low risk fuels treatment of State and Federal lands in close proximity to private property should be implemented earliest in the selected alternative.

Fuel breaks included in any selected alternative need to be implemented early in the implementation process in order to increase protection of wildland/urban interface residents.

Higher risk forms of fuels treatment need to be implemented by stages. Any planned fuels treatment in close proximity to private property should take place prior to any broad based use of prescribed fire in adjacent areas. Burning of piles usually takes place during periods of low risk, so can take place at any time of year.

5. Fisheries Recommendations

6. Wildlife Recommendations

Update the current data and GIS data layer on vegetative composition and structure. Assess the current structural distribution by vegetation type. Manage for diversity of structures; approximately 25% in each stand development class.

Implement habitat improvement projects that enhance wildlife habitat diversity.

Projects should meet the following objectives:

Promotion of old growth complexes or large blocks of existing and developing old growth in all vegetation types, including hardwoods.

Promotion of hardwood and spruce regeneration by patch cutting, burning, or maintaining existing spruce regeneration stands through thinning.

A combination of mechanical fuels reduction, thinning to promote structural diversity and reduce completion to promote growth, and prescribed burning will reduce fuels, and improve vegetative and structural diversity over time.

<u>Burns</u> should be conducted to emulate natural disturbances caused by fire, avalanche or flooding and to remove large tracts of dead and falling spruce stems. Selection of sites will be dependant on a variety of factors, including slope, aspects, adjacency to streams, air quality, terrain, and public safety, and potential to regenerate trees rather than grasses such as Calmogrostix canadensis.

Mechanical/Hand Harvest of Trees, Regeneration of Spruce and Hardwoods

Cut patch sizes of fewer than 10 acres to emulate natural disturbances and promote regeneration and natural succession processes. In some cases it will be necessary to replant the cut areas with native spruce or to reseed with native birch seed. Management goal would be to create a vegetation mosaic within the natural range of variation. Mechanical techniques can include harvesting of standing dead or live-at-risk trees, and removal and stacking of downed material. Cutting and removal of fuels would reduce fire risk and promote regeneration of early successional communities. Retain snags and downed woody material that provides habitat to wildlife species as stated in the forest plan. Leave some slash piles for browse (hardwood slash) or small mammal habitat (conifer slash).

Monitor and carefully plan recreation opportunities to enhance wildlife viewing and education while reducing potential disturbance to wildlife and safety conflicts, especially with brown bears.

Develop management plans and implement inventory, monitoring, and habitat improvement projects for each MIS, TES, and SSI listed in the revised Forest plan. Coordinate as needed with the USFWS and AFG.

Bear: Brown bear habitat can be maintained or improved by improving moose winter range, maintaining or improving riparian habitat quality, limiting development near salmon streams, reducing risk of bear human interactions through sensible recreation planning and public education**.**

a) Implement Moose habitat improvement projects.
b) Education projects on bear/human interactions at local schools.
c) Install educational signs at sites with higher risk of bear human interactions.
d) Install bear proof food containers at remote camp spots.
e) Look for problem areas along trails (tight turns, low visibility, near anadromous streams), and reroute trails or put up signs warning of bear encounters and how to deal with them.
f) Work with USFWS and AFG to identify and map wolf habitat, and monitor population and habitat trends, and coordinate on a bear management plan.

Brown Bears require cover near feeding areas. w.shuster

Moose:

Maintaining or increasing early successional stages in hardwoods and maintaining high quality riparian habitat can improve moose habitat. Prescribed fire and small timber sales can improve the amount and distribution of winter range (below 1000'), and in combination with selective thinning can create browse and promote growth of large trees and cover in adjacent areas.

a) Create patch cuts of various sizes and shapes between Hope Wye and Johnson Pass Trail on either side of the Seward Highway to regenerate hardwoods and spruce.

b) Promote hardwood regeneration near the Mile 62 pit. Work in combination with fisheries to fill in the pit with water, create ponds, and create some moose habitat. There is potential to create a moose viewing area here, with interpretive information on moose ecology.

c) Promote hardwood regeneration near the bog off Palmer Creek Road, various areas along Palmer Creek Rd, south of the Hope Wye along the Seward Highway.

d) Implement prescribed burning to promote hardwood regeneration east of Six Mile Creek, ……………………….

Mountain Goat

Winter habitat can be maintained or improved by retaining or promoting old growth habitat and hemlock, especially near steep alpine cliffs and rocky areas, and restricting aircraft over flights to keep them short term and limited in duration.

a) Identify and map old growth and developing old growth areas within the watershed. Identify habitat improvement projects to enhance old growth characteristics near steep alpine cliffs and rocky areas.
b) Identify and map goat summer and winter range. Identify and map recreation activities that overlap these areas and monitor to identify areas of conflict or disturbance.

Gray Wolf

Maintaining abundant populations of prey species, controlling access on new roads and working with ADFG to reduce or eliminate illegal harvest are the primary mitigation measures considered maintaining healthy populations. In the Six Mile watershed, improving moose habitat would be the primary method for maintaining wolf populations.

a) Implement Moose #1
b) Review Stacy Prosser's masters thesis on caribou and look for opportunities to improve caribou habitat.

c) Review literature and consider opportunities to improve mountain goat and Dall sheep habitat.
d) Work with USFWS and AFG to identify and map wolf habitat, and monitor population and habitat trends, and coordinate on a wolf management plan.

Lynx

In Six Mile watershed, maintaining or promoting early stages of spruce and hardwood forests and vegetative diversity will promote or maintain lynx habitat.

a) Implement Moose #1

Marbled Murrelet

Old growth habitat, which could serve as potential nesting habitat in the Six Mile watershed is being lost due to the impacts of the spruce bark beetle. Old growth habitat that is not infected, especially within 5 miles of the coast, should be maintained, and old growth characteristics such as large trees and structurally complexity could be promoted through thinning in mature stands to enhance or create nesting habitat. The best potential nesting habitat occurs within 0.5 miles of the coast, within 0.5 miles of Six Mile Creek, and some areas adjacent to Palmer Creek.

a) Identify and map old growth areas within the watershed. Identify current bark beetle infestation or potential to be infected. Predict old growth availability over the next 30 years. Identify areas to maintain and areas to develop over time to create or maintain spatial diversity throughout the landscape.

River Otter

In the Six Mile watershed, due to the increasing losses of old growth habitat from the spruce bark beetle, high quality habitat for otters may be declining. Efforts to promote or maintain mature or old growth trees, canopy cover, and snags adjacent to coastal and fresh water environments will help maintain otter populations.

c) Identify and map old growth and developing old growth areas within the watershed. Identify habitat improvement projects to enhance old growth characteristics near ponds and lakes.

Townsend's warbler

Mature and old growth habitat is being lost due to the impacts of the spruce bark beetle. Old growth habitat that is not infected should be maintained, and old growth characteristics such as large trees and structurally complexity could be promoted through thinning in mature stands to enhance or create potential habitat.

a) Identify and map old growth and developing old growth in spruce. Identify habitat improvement projects to enhance old growth characteristics, and distribute throughout the landscape.

Wolverine

In the Six Mile watershed, maintaining habitat for large animals such as moose, sheep, goats, and caribou, and identifying and reducing human disturbance to potential denning sites will be important to maintaining populations.

a) Implement moose habitat improvement projects.

b) Conduct surveys to identify existing and potential wolverine denning and foraging habitat. Identify potential areas of conflict or disturbance from motorized winter recreation.

Bald Eagle

Habitat management in the Six Mile watershed should focus on retaining large old cottonwoods for nesting habitat, promoting future nesting habitat, and reducing disturbance near nest trees.

a) Identify current distribution and age structure of cottonwoods in the watershed. Identify habitat improvement projects or protection measures if necessary. Continue annual monitoring of existing bald eagle nests and inventory of new nests. Monitor recreation activity and disturbance near known nests.

Goshawk

Mature and old growth habitat is being lost due to the impacts of the spruce bark beetle. Old growth habitat that is not infected should be maintained, and old growth characteristics such as large trees and structural complexity could be promoted through thinning in mature stands to enhance or create potential habitat. Some nesting habitat can be promoted in mature hemlock stands by thinning to reduce competition, increase growth, and open the under story, while retaining denser canopies. This may help replace losses of some nesting habitat in mature spruce due to the bark beetle.

a) Implement Goshawk nesting habitat improvement projects identified in the Hope Highway EA.

b) Implement nesting habitat improvement projects in mature hemlock stands adjacent to Palmer Creek Rd, and on the West side of the Seward Highway south of the Hope Wye.

<u>Osprey</u>

Management in the Six Mile watershed should include maintenance of healthy riparian areas, and nest searches in areas of any reported osprey sightings, with protection of any discovered nest sites as identified in the Forest plan.

<u>Trumpeter Swan</u>

Management for the Six Mile watershed should include aerial surveys of all water bodies in and adjacent to the watershed during the breeding season, and nest protection (0.5 mile buffer) as identified in the forest plan if nests are located.

a) Design and conduct swan surveys during the breeding season. Identify and map existing and potential habitat. Identify areas of potential disturbance due to recreation activities.

7. Vegetation/ecology recommendations

The strongest recommendation in the assessment area is the continued management of forested vegetation, which is warranted by the widespread effects of the spruce bark beetle epidemic. The two major concerns that arise without planning continued management include 1) an increased fuel loading causing fire risk to communities and structures, and 2) the alteration over time of stand structural diversity leading to decreased wildlife habitat quality and an overall decline in the health of the forested ecosystem. An overall management plan will have several components that can be adapted and applied to varying degrees, as needed depending on funding, public sentiment, individual project area issues, and climatic events. A good plan for management will balance cost of the program, the amount of risk to resources (such as reduction of water or air quality, effects on fisheries or wildlife habitat, increase in nonnative or noxious weed species, threats to cultural resources), the amount of risk to human life or property (such as escaped prescribed burns, increased catastrophic wildfire risk), changes in recreational quality of the area, and economic effects on communities.

Although the current spruce bark beetle infestation and its potential effects on plant community structure is within the range of historical variation, the current presence of communities, properties, and structures makes the amount of potential risk to private property and human health an important decision-making criteria.

The Seward Ranger District is in the first phases of an overall fuel reduction strategy, planned for 2003 through 2009. Management in this assessment area would be included in the plans of a combination of mechanical fuels reduction and a prescribed burn program. The first phases of this program include mechanical fuels reduction activities in areas directly adjacent to communities where there is significant risk to life and property in the event of a catastrophic wildfire. The Hope Highway Project (2002) aims to mechanically reduce fuel around the community of Sunrise. Within the assessment area, there are other areas with opportunity for management activity.

Balancing the Mosaic of Stand Development Stages and Species

The main purpose in vegetation management within the assessment area is to maintain vegetation composition and structure within the range of historical variability while minimizing risks to property and human health caused by catastrophic wildfire. In the overall landscape, mix of 25% of each of the four stand structure stages is ideal, with an appropriate mix of species types for various wildlife species. Working with what is present on the ground today, a carefully planned program can work towards creating and maintaining these desired conditions. Target areas should first include areas around property, road corridors, campgrounds, trails, and other areas that visitors and residents live in and use recreationally.

Mechanical or Hand Harvest of Trees for Fuels Reduction

Recommended silvicultural prescriptions include patchcutting less than 10 acres per patch to emulate natural disturbances and promote regeneration and natural succession processes. In many areas planting of native spruce seedlings will be necessary to facilitate establishment of a healthy spruce stands, particularly in areas where competition from Calamagrostis canadensis (bluejoint reedgrass) is strong. Large clearcuts could promote the establishment of this grass, which prevents regeneration of tree species. The bluejoint reedgrass is a highly productive species and competitive grass and can create an extremely flashy fuel load. It shades out in 30 years or so under the forested overstory, once developed. Silvicultural treatments should be carefully planned to avoid sites susceptible to dominance by reedgrass following treatment (Boucher Thesis 2001). The management goal would be to create a vegetation mosaic (in terms of stand development stages and species distribution) of stands within the natural range of variation. Mechanical techniques can include harvesting of standing dead or live-at-risk trees, and removal and stacking of downed material. Cutting and removal of fuels would reduce fire risk and promote regeneration of early successional communities. Negative elements to this management strategy include the loss of snags and downed woody material that provides habitat to wildlife species and an immediate reduction in downed woody material recruitment. Some retention of snags in patches can occur, and some slash piles can be left alone for a season to provide browse for moose (in birch and hardwood stands) and then burned the following year. Other stands could have slash lopped and scattered for wildlife habitat concerns, although the presence of spruce bark beetle may make this technique undesirable for several years. Logistics of access to some areas within the assessment area may make hand harvest techniques feasible. Areas across Sixmile Creek or Canyon Creek from the road system provide challenges due to the canyons and terrain to mechanical harvest equipment. In this case hand harvest could occur with associated piling and burning of slash.

The most targeted stand development stage for management activity is the Understory Reinitiation stage, which has the most acreage. With mechanical harvest in stands, they will be returned to the stand initiation stage, setting the stage for future stem exclusion and understory reinitiation stages. Current old growth stage areas are limited, and some understory reinitiation stage stands, particularly hemlock and spruce-hemlock composition stands, could be "nudged" towards old growth development by selective thinning to mimic natural patch disturbance within these stands. These old growth and late understory reinitiation stage stands have a distinct appearance on aerial photos within the assessment area, appearing as thick vegetation cover with pockmarks scattered throughout, at as such are good candidates for selection by stand for management activities. With the spruce bark beetle epidemic, many spruce stands will return to the stand initiation stage on their own but many not be able to naturally regenerate due to amount of downed woody material, so piling and burning on these stands will create a natural seedbed for spruce seedlings to establish, although planting may still be necessary.

In terms of species distribution, the presence of extensive stands of mature birch and other hardwood presents a special challenge, as well as opportunities for management. Some of the mature birch stands have a spruce understory, and with thinning of the mature birch overstory spruce growth will be encourage. This will create new spruce stands to replace those that have been eliminated by the spruce bark beetle epidemic. Approximately 10% of the birch stands in the assessment area are good candidates for conversion to healthy spruce stands. Overall, the most abundance size classes for birch are seedling/sapling and pole, ensuring a continued component of birch across the landscape, which is important for moose and other species habitat, and is favored for its scenic qualities by visitors and residents. Small patchcuts within these stands would increase forested stand diversity and as well as habitat for moose by introducing spruce or spruce-hemlock patches within the mature birch stands, and promoting a variety of birch stand ages. Patchcutting of mature birch stands should occur before age 100 to encourage sprouting of new birch trees, and continue the mix of stand ages over time.

In existing spruce and spruce-hemlock stands, salvage and sanitation cutting of dead spruce and patchcutting of mature live spruce is recommended for fuels reduction, stand diversity increase, and patches of new healthy spruce growth. Planting may be necessary in the patchcuts and cleared areas to establish spruce growth. Pure hemlock stands should be thinned in areas where the trees have more or less stopped growing within the stem exclusion phase, to encourage movement to understory reinitiation stage and eventually old growth.

In cottonwood stands, mainly along the stream corridors, small patch cuts of less than one acre in size are recommended to encourage regeneration. Cottonwood stands are generally found in small patches of even-ages trees due to the dynamic nature of Sixmile Creek and Canyon Creek stream channels over time. Current distribution by size is mostly pole and mature stands. Old growth stands should be retained with no cutting for their unique aesthetic character and habitat qualities.

Prescribed Burning

Prescribed burning is a potential land management activity that is worked into the long-term plans for various areas within the Seward Ranger District. Public reception of prescribed burns is variable after the escaped Kenai Lake burn in summer of 2001. Initiation of various burn units may be possible in summer of 2003. Burns should be conducted to emulate natural disturbance of fire dependent species and remove large tracts of dead and falling spruce trees. Selection of sites would be dependant on a variety of factors, including slope, aspects, adjacency to streams, air quality, terrain, adjacency to property and structures, and public safety. There are many opportunities for burns along the Hope Highway corridor south of the community of Sunrise where slope conditions, road corridors, and Sixmile Creek may provide natural fuel breaks to prevent escaped burns and other risks. In addition, there are areas along the Seward Highway within the assessment area north of Canyon Creek that may have good potential for prescribed burns. Camping areas within the assessment area should have a strong fuel reduction program.

Around the community of Sunrise a fuel break is recommended until further prescribed burn activities and fuel reduction harvests take place, along with an educational program to inform residents of preparation for wildfire to prepare their properties and decrease fire risk on their property. Most ignitions in this areas result from a human source, so education can also reduce the risk of ignition. This would involve the removal of ladder fuels, snags, and dead and down woody debris immediate around the properties and around the margins of the community. Additional activities would include the recommended thinning, selective mechanical or hand harvest of dead spruce, and piling and burning of slash and down spruce trees.

Additional Recommendations

All activities and projects conducted should include monitoring noxious weed and nonnative species populations and population spread. Early detection of populations will give insight as to how populations arrive and are spread within the part of Alaska, and may provide educational or prevention opportunity in other areas. Projects that require any kind of machinery should be free of seed sources for the spread of noxious weeds or nonnative before arriving at the project site. With the amount of river systems within the assessment area, there is opportunity for quick spread of certain species once introduced into the ecosystem. In addition, the amount of fuel reduction activities that will take place can introduce nonnatives into the ecosystem. Mechanical harvest equipment often leaves the road system and enters stands within core area of the forested section, and road building can provide new vectors for seeds or plants to travel within. The more ground disturbing activities that take place, the higher the risk is for plant populations to become established and spread into non-disturbed areas. Prescribed burning activities create large tracts of open seedbed for stray seeds to germinate. Care should be taken in these areas to prevent noxious weed and nonnative species establishment through handpulling if populations are noted or possibly herbicidal measures.

Monitoring and survey of sensitive plant populations should continue to track changes in habitat as fuel reduction activities, prescribed burning, and continued fall of infested and dead trees occurs.

Literature Cited

Alaska Dept. of Natural Resources. 1993. _Kenai Peninsula Spruce Beetle Wildland Fire Consequences.

Alaska Heritage Resource Survey. 2000. Alaska Heritage Resource Files. Office of History and Archaeology. Anchorage, AK.

Alaska Interagency Fire Management Council 1993. Alaska Consolidated Interagency Fire Management Plan, Operational Draft.

Alaska Interagency Fire Management Council (no date) Managing Wild Fire Alaska...and smoke too, brochure.

Alden, D. 1995a Archaeological Survey Report: Sixmile Creek Drainage, Unit 11. IS&A FY95-04-47. On file, CNF Supervisor's Office, Anchorage, AK.

1995b Archaeological Survey Report: Sixmile Creek Drainage, Unit 16. IS&A FY95-04-52. On file, CNF Supervisor's Office, Anchorage, AK.

1996 Alder Creek Timber Harvest Unit, IS&A FY96-04-23. On file, CNF Supervisor's Office, Anchorage, AK.

Bailey, Robert. October, 1993. National Hierarchy Framework of Ecological Units. ECOMAP, USDA Forest Service, Washington, D.C.

Bangs, E.E., T.H. Spraker, T.N. Bailey, and V.D. Berns. 1982. Effects of increased human populations on wildlife resources of the Kenai Peninsula, Alaska. In Proceedings of the 47th North American Wildlife Conference. Page 605-616.

Barry, Mary J. 1973. A History of Mining on the Kenai Peninsula, Alaska. Alaska Northwest Publishing Company.

Bellrose, F.C. 1976. Ducks, geese and swans of North America. Stackpole Books. Harrisburg, Penn. Pages 380-384.

Blackstock, D. 1993. Recommendations for Operational Control of the Beetle of Alaska's Spruce Forests, Blanchet, D., 1981. Water Quality Effects of Placer Mining on the Chugach National Forest, Kenai Peninsula, Field Season, 1980. Chugach National Forest, US Forest Service, Alaska Region, US Department of Agriculture, 23 pp.

Blanchet, D., 1986. Climatic Evaluation of Potential Winter Sports Development Sites on the Chugach National Forest. USDA Forest Service, Chugach National Forest, Anchorage, Alaska.

Blanchet, D. 1987. Fire History on the Kenai Peninsula Portion of the Chugach NF, 1914-1986, DRAFT

Boucher, T. 2001. Vegetation Response to Prescribed Fire in the Kenai Mountains, Alaska. MS Thesis, University of Oregon and USDA Forest Service.

Boughten, J. and M. Shephard. 2002. Invasive plants in Alaska – a chance to catch the problem early. Western Forests 47(3): 12-13.

Buskirk, S.W. and L. F Ruggiero. 1994. American marten. In The Scientific Basis for Conserving Forest Carnivores in the Western United States: American Marten, Fisher, Lynx and Wolverine. USDA Forest Service Gen. Tech. Report RM-254. Pages 7-37.

Buzzell, Rolfe G., and J. David McMahan. 1986. Cultural Resources Survey of the Seward Highway, Milepost 50-65.5, Kenai Peninsula, Alaska. Anchorage: Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation, Office of History and Archaeology.

Collins, W. B., 1992. Wildlife Habitat Enhancement in the Spruce-Hardwood Forest of the Matanuska and Susitna Valley, Alaska Dept. of Fish and Game, Project W-23-5, Study #1.44.

Copeland, J.P. 1996. Biology of the wolverine in central Idaho. MS Thesis. Univ. Idaho. 138pp.

Cowardin, Lewis M. et al. 1979. Classification of Wetlands and Deepwater Habitats of the United States. Fish and Wildlife Service. U.S. Department of the Interior. FWS/OBS-79/31.

Davidson, D., 1997. Ecological Hierarchy of the Chugach National Forest, updated 5/19/99. Unpublished internal report.

Davidson, D. 1989, Kenai Road Corridor Soil Survey. Chugach National Forest, USDA Forest Service, Alaska Region, R10-TP-16.

Davis, Arlene, *et al*. 1980. Soil Resource Inventory of the Kenai Peninsula, Chugach National Forest. USDA Forest Service. Alaska Region. Report Number 110

Densmore, R. V., and Page, J. C. (unknown date). Paper Birch Regeneration of Scarified Logged Areas in Southcentral Alaska, Northern Journal of Appl. Forestry, 9(2) 63-66

DeVelice, R. L., C. J. Hubbard, K. Boggs, S. Boudreau, M. Potkin, T. Boucher, and C. Wertheim. 1999. Plant Community Types of the Chugach National Forest: Southcentral Alaska. USDA Forest Service, Alaska Region, Technical Publication R10-TP-76, Anchorage, AK.

Ecology and Environment, Inc., 1995. Summary Report Site Discovery Project, Mills Creek Mine, Chugach National Forest, Alaska, Prepared for USDA Forest Service, Alaska Region, March 1995.

Ellison, L. N. 1975. Density of Spruce Grouse Before and After Fire.

Fahnestock, G. R. 1970. Two Keys for Appraising Forest Fire Fuels.

Foote, J. 1976. Classification, Description and Dynamics of Plant Communities Following Fire in the Taiga of Interior Alaska.

Fox, J. 1980. Forest Regeneration of Upland Areas Following Logging in Interior Alaska.

Golden, H.N. 1996. Furbearer management technique development . Fed. Aid in Wildl. Restore. Research Progress Rep. W-27-1. Alaska Dept. Fish and Game, Anchorage, Alaska. 24pp.

Grundman, Donna and Don Ohr. 1986. A Place Called Hope: Its history was carved from GOLD. The authors, Hope, AK

Hoekzema, R.B., 1985, Mineral deposits and mining history of the Kenai Peninsula area in Guide to the geology of the Kenai Peninsula, Alaska, Alaska Geological Society, p. 73-87.

Hoekzema, R.B., and Sherman, G.E., 1983, Mineral Investigations in the Chugach National Forest, Alaska (Peninsula Study Area), In-house report, U.S.D.I. Bureau of Mines, Anchorage, Alaska, 526 p.

Holsten, E. H., R. A.Werner and R. DeVelice. 1994. Spruce Bark Beetle, Dendroctonus rufipennis(Coleoptera: Scolytidae), Outbreak and Prescribed Fire Affect Stand Volume, Structure, and Ground Vegetation, 1994, DRAFT.

Holsten, E., P. Hennon, L. Trummer, and M. Schultz. 2001. Insects and Diseases of Alaskan Forests. USDA Forest Service, Alaska Region, AK.

Holsten, E. H., R. A. Werner, and R. L. DeVelice. 1995. Effects of a spruce beetle outbreak and fire on Lutz spruce in Alaska. Environmental Entomology. December 1995. Pp. 1540-1547.

Huber, C. and Blanchet, D., 1992. Water Quality Cumulative Effects of Placer Mining on the Chugach National Forest, Kenai Peninsula, 1988-1990. Chugach National Forest, US Forest Service, Alaska Region, USDA.

Iverson, G.C., G. Hayward, K. Titus, E. Degayner, R. Lowell, D. Crocker-Bedford, P. Schempf, and J. Lindell. 1996. Conservation assessment for the Northern Goshawk in Southeast Alaska. USDA Forest Service PNW-GTR-387. 101pp.

Jansons, U., Hoekzema, R.B., Kurtak, J.M., and Fechner, S.A., 1984, Mineral occurrences in the Chugach National Forest, south-central Alaska: U.S. Bureau of Mines Report MLA5-84.

Knecht-Levine, Rosemarie. 1983. Hope. *In* A Larger History of the Kenai Peninsula. Elsa Pederson, ed. Chicago: Adams Press.

Lieffers, V.J., and MacDonald, S.E. 1993. Ecology of and Control Strategies for Calamagrostis Canadensis in Boreal Forest Sites.

Lieffers, V.J., and Stadt, K.J. 1993. Growth of Understory *Picea glauca*, *Calamagrostis canadensis*, and *Epilobium angustifolium* in Relation to Overstory Light Transmission.

Lipkin, R. and D. F. Murray. 1997. Alaska Rare Plant Field Guide. USDI, Washington, DC.

Lutz, H.J. 1960. Early occurrence of moose on the Kenai Peninsula and in other sections of Alaska. USDA, Forest Service. Juneau, Alaska. Misc. Publ. No.1. 25pp.

Magoun, A.J. 1995. Wolverines head for the hills on the Kenai Peninsula. Poster Paper. Preceed. 8th North. Furbearer Conf., Anchorage, Alaska. 19pp.

March, G.D. and Robertson, L.G., 1982. Snow Avalanche Atlas, Seward Highway, South-Central Alaska. State of Alaska, Department of Natural Resources Professional Report 81, Division of Geological and Geophysical Surveys.

Martin, G.C., Johnson, F.L., and Grant, U.S., 1915, Geology and mineral resources of Kenai Peninsula, Alaska: U.S. Geological Survey Bulletin 587, 243 p.

McCart, Dennie. 1983. The Hope Truckline and 75 miles of Women. Portland: Binford and Mort.

Mishler, Craig. 1985. Historical Demography and Genealogy: The Decline of the Northern Kenai Peninsula Tanaina. Alaska Department of Natural resources, Division of Geological and Geophysical Surveys. Anchorage, Alaska.

Mitchell, P.A., 1979, Geology of the Hope-Sunrise (Gold) Mining District, North-Central Kenai Peninsula, Alaska. MS Thesis, Stanford University, 123 pp.

Moffit, F.H., 1905, Gold placers of Turnagain Arm, Cook Inlet: U.S. Geological Survey Bulletin 259, p. 90-99.

Moffit, F.H., 1906, Gold fields of the Turnagain Arm region: U.S. Geological Survey Bulletin 277, p. 7-52.

Nelson, S.W., Miller, M.L., Barnes, D.F., Dumoulin, J.A., Goldfarb, R.J., Koski, R.A., Mull, C.G., Pickthorn, W.J., Jansons, U., Hoekzema, R.B., Kurtak, J.M., and Fechner, S.A., 1984, Mineral Resource Potential of the Chugach National Forest, Alaska Summary Report to accompany Map MF 1645-A, U.S.D.I. Geological Survey, Alaska, 23 p.

Nelson, S.W., Dumoulin, J.A., and Miller, M.L., 1985, Geologic Map of the Chugach National Forest, Alaska, Miscellaneous Field Studies Map MF-1645B, scale 1:250,000.
Newton, M. and Cole, E. C. 1990. Vegetation Management in the Rehabilitation of the Cooper Landing Beetle Outbreak Area, Chugach NF, Seward RD.

Oliver, C.D., & B.C. Larson. 1996. Forest Stand Dynamics. John Wiley & Sons, New York. 424 p.

Omi, P.N., Kalabokidis, K. D.1991. Fire Damage on Extensively Managed Forest Stands Within The North Fork Fire, 1988.

Paige, S., and Knoph, A., 1907, Reconnaissance in the Matanuska and Talkeetna basins, Alaska, with notes on the placers of the adjacent regions: U.S. Geological Survey Bulletin 314, p. 104-125.

Potkin, M. 1997. Fire history disturbance study of the Kenai Peninsula mountainous portion of the Chugach National Forest. DRAFT Report. USDA Forest Service, Chugach National Forest. Anchorage, Alaska. 63pp.

Powelson, R. A., and Lieffers, V.J.1992. Effects of Light and Nutrients on Biomass Allocation in Calamagrostis canadensis.

Reed, L. 1993. Realizing the Potential of Alaska's Forest Resources, State of Alaska Dept. of Natural Resources.

Renecker, L.A. and C.C. Schwartz. 1998. Food habits and feeding behavior. In Ecology and Management of the North American Moose. Wildl. Manage. Institute. Smithsonian Institue Press. Washington and London. Page 403-439.

Rivard, P. G., and Woodard, P. M, anmd Rothwell, R. L. 1989. The Effect of Water Table Depth on White Spruce(Picea glauca) Seedling Growth in Association with the Marsh Reedgrass (Calamagrostis canadensis, on Wetland Soil).

Rosenburg, R., S. Patton, and T. Rothe. 1994. Harlequin duck. In Alaska Wildlife Notebook Series. ADF&G, Anchorage, Alaska. 2pp

Rounsaville, Marc, 1993. Fuels Analysis of the Seward Ranger District, Chugach NF.

Schulz, Beth. 1995. Technical Report R10-TP-XX Changes Over Time In Fuel Loading Associated With Spruce Beetle-Impacted Stands of the Kenai Peninsula, Alaska.

Schwaderer, George C., Inc., 1994. Hydrology and Hydraulics Study for Project IR-OA3-2(4)/58673, Seward Highway Mile Post 54.8 to 59.3. Prepared for R&M Consultants, Inc., Anchorage, AK, for Alaska Department of Transportation and Public Facilities, Central Region, Anchorage, AK.

See, J. 1990. Cooper Landing Spruce Beetle Fire Behavior Analysis.

Seitz, Jody; Tomrdle, L. and J. Fall. 1992. The Use of Fish and Wildlife in the Upper Kenai Peninsula Communities of Hope, Whittier, and Cooper Landing. Alaska Department of Fish and Game, Subsistence Division. Anchorage, Alaska.

Sherman, G.E., Williams, E.M., and Meyer, M.P., 1997, Mineral materials survey of the Seward and Glacier Ranger Districts road corridor, Chugach National Forest, Alaska, Bureau of Land Management, Alaska State Office, 2 Vol.

Suring, L.H., K.R. Barber, C.C. Schwartz, T.N. Bailey, W.C. Shuster, and M.D. Tetreau. 1998. Analysis of cumulative effects on brown bears on the Kenai Peninsula, Southcentral Alaska. Ursus 10: 107-117.

Swanston, Douglas N. Marrch, 1997. Controlling Stability Characteristics of Steep Terrain. With Discussion of Needed Standardization for Mass Movement Hazard Indexing: A Resource "Assessment. Included in Assessments of Wildlife Viability, Old-Growth Timber a Volume Estimates, Forested Wetlands, and Slope Stability., General Technical Report PNW_GTE-392. Mp. 44-58.

Taylor, R. J. 1990. Northwest Weeds: The Ugly and Beautiful Villains of Fields, Gardens, and Roadsides. Mountain Press Publishing Company, Missoula, MT.

Teie, W. C. 1994. Firefighter's Handbook on Wildland Firefighting.

Tysdal, R.G., and Case, J.E., 1979, Geologic map of the Seward and Blying Sound quadrangles, Alaska: U.S. Geological Survey Miscellaneous Investigation Series Map I-1150, scale 1:250,000.

United States Fish and Wildlife Service. 1993. Kenai Peninsula units 7 and 15. Customary and Traditional Use Determination Report. Anchorage, Alaska.

Alaska Department of Environmental Conservation, 1999. 18 AAC 70 Water Quality Standards, as amended through May 27, 1999.

USDA. Forest Service. 1978 Effects of Fire on Flora.
.
USDA Forest Service, Chugach NF, Seward RD 1990. Cooper Landing Cooperative Project Environmental Assessment.

USDA Forest Service, Alaska Region, 1992. A Channel Type Users Guide for the Tongass National Forest, Southeast Alaska. R10 Technical Paper 26, 179 pages.

USDA Forest Service. 1993. Fire Effects Information System for: Bluejoint Reedgrass, White Spruce, Paper Birch and Red Alder.

USDA Forest Service. 1993. Healthy Forests For America's Future.

USDA Forest Service. 1995 Forest Service Manual 5100, Fire Management.

USDA Forest Service, Alaska Region, 1996. Sixmile Salvage Sales Environmental Assessment. Public Law 104-19, Section 2001, R10-MB-324.

USDA Forest Service. 1995. Programmatic Agreement Among the United States Department of Agriculture - Forest Service, Alaska Region; the Advisory Council on Historic Preservation; and the Alaska State Historic Preservation Officer, Regarding National Historic Preservation Act, Section 106 Compliance in the Alaska Region of the Forest Service, United States Department of Agriculture. On file, USDA Forest Service, Anchorage, AK.

USDA Forest Service, 1996-2000. Chugach National Forest Corporate GIS Data Layers. Contours (updated 1997), Cover types (updated 1997), Ecosections (updated 1997), Geology (updated 1997), Lakes (updated 1998), Land status (updated 2000), Roads (updated 2000), Streams (updated 1999), Watersheds (updated 1997), Wetlands (updated 1997).

USDA Forest Service. 2001. Chugach National Forest Resource Information Management Data Dictionary. December 6th

USDA Forest Service. 2002. Hope Highway Environmental Assessment. USDA Forest Service, Region 10.

USDA Forest Service. 2002. Revised Land and Resource Management Plan.

US Geological Survey, 1994. Magnitude and Frequency of Floods in Alaska and Conterminous Basins of Canada. Water Resources Investigations Report 93-4179, prepared in cooperation with the State of Alaska Department of Transportation and Public Facilities and the Federal Highway Administration.

US Geological Survey, 2002. Alaska National Water Inventory System Website Data Retreival Page. http://www.water.usgs.gov/ak/nwis. Downloaded May 2002.

Van Cleve, K., Dyrness, T., Viereck, L. 1994. Fire: Examining Its Forest Regeneration Potential.

Vanderlinden, L. 1991. Fire Behavior Considerations for Cooper Landing Contingency Plan.

Vanderlinden, L. 1991. Fire Behavior Narrative of the Pothole Lake Fire

Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska Vegetation Classification. USDA Forest Service, Pacific Northwest Research Station, PNW-GTR-286, Alaska.

Vogl, R. 1976. A Primer of Ecological Principles, Book One.

Voss, J., 1992, Mineral Report Surface Use Determination for the: Big Rock and Betty #1 Placer Mining Claim Placer Mining Claims, USDA Forest Service, Alaska Region, Juneau, Alaska, 38 p.

Voss, J., 1992, Mineral Report Surface Use Determination for the: Cascade, Cascade Number Two - Five Placer Mining Claims, USDA Forest Service, Alaska Region, Juneau, Alaska, 36 p.

Voss, J., 1992, Mineral Report Surface Use Determination for the: Discovery #1-3 and Discovery #7-10 Placer Mining Claims, USDA Forest Service, Alaska Region, Juneau, Alaska, 39 p.

Voss, J., 1992, Mineral Report Surface Use Determination for the: Heaven's Gate #1 - #5 Placer Mining Claims, USDA Forest Service, Alaska Region, Juneau, Alaska, 35 p.

Voss, J., 1992, Mineral Report Surface Use Determination for the Roaring Placer Mining Claim, USDA Forest Service, Alaska Region, Juneau, Alaska, 38 p.

Weixelman, D. 1987. Prescribed Burning For Moose Habitat Improvement on the Chugach NF, Alaska.

Werner, R. A. 1982. The Spruce Beetle in Alaska Forestry.

Western Regional Climate Center, 2002. Alaska Climate Summaries Webpage. http://www.wrcc.dri.edu/summary/climsmak.html. Downloaded May 2002.

Wilson, D. Wolverine. In Wild Mammals of North America: Biology, management and economics. Johns Hopkins Press. Baltimore and London. Page 644-652.

Wimmler, N.L., 1926, Brewster Quartz Property, Unpublished Terr. Of Alaska, Dept. of mines Report, available upon request from the U.S.D.I. Bureau of Land Management (formerly U.S. Bureau of Mines), Juneau, Alaska.

Winkler, R.G., Miller, M.L., Hoekzema, R.B., and Dumoulin, J.A., 1984, Guide to the bedrock geology of a traverse of the Chugach Mountains from Anchorage to Cape Resurrection: Alaska Geological Society, 40 p.

Wittwer, Dustin (compiler) 1998. Forest Insect and Disease Conditions in Alaska – 1998. General Technical Report R10-TP-74. USDA, USFS, Alaska Region. 57 pp.

Zasada, J. C. and L. A. Viereck. 1970. White spruce cone and seed production in interior Alaska, 1957-68. USDA, For. Ser., PNW For and Range Exp. Sta. Research Note. PNW-129.

Zasada, J. C. 1972. Guidelines for obtaining natural regeneration of white spruce in Alaska. USDA, For. Ser., PNW For. And Range Exp. Sta. Res. Note PNW-XX.